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INTERNATIONAL SPACE

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HIGH FRONTIER

The Journal for Space and Cyberspace Professionals

February 2010 — Volume 6, Number 2

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Introduction

General C. Robert Kehler
Commander, Air Force Space Command

Like air, land, sea, and cyberspace, the space domain is vital to our nation's military, civil, and commercial interests. Space has had an international dimension since the first satellites went into orbit. However, the growing importance of space as an enabler of global communication, transportation, commerce and warfighting effectiveness, and the increasing number and sophistication of space-faring and space-consuming nations places the international dimension in a new light. While increased international presence in space and highly sophisticated foreign capabilities can present challenges for US national security, they can also present opportunities to enhance our security. Serious policy and operational questions exist regarding increased international cooperation. This quarter's *High Frontier* is devoted to "International Space" and presents intriguing perspectives from preeminent representatives of government, academia, and industry.

The "Senior Leader Perspective" section begins with an insightful article by Mr. Richard W. McKinney, European space liaison, Office of the Undersecretary of the Air Force, Headquarters US Air Force, Washington, DC. Mr. McKinney uses three historical events to frame his advocacy for increased military international space cooperation and then provides key guidelines, developed from National Aeronautics and Space Administration's (NASA) decades of success, to effectively deal with the inherent complexity of international cooperation.

Air Commodore Jan A. H. van Hoof, Royal Netherlands Air Force, assistant director capabilities, Joint Air Power Competence Centre, Kalkar, Germany, concludes the "Senior Leader Perspective" by advocating for increased North Atlantic Treaty Organization (NATO) space cooperation through an emphasis on better integration of existing capabilities and through the establishment of a NATO space office and space operations coordination center.

This quarter we provide nine compelling articles in the "International Space" section. Dr. Peter Hays and Mr. Dennis Danielson lead with a discussion on potential security improvements possible through enhanced international cooperation. Then, Dr. Joan Johnson-Freese provides a thought provoking piece on challenges associated with expanding space cooperation with China and suggests some steps that Air Force Space Command could take to improve cooperation in the future. Third, Dr. T. S. Kelso presents recommendations on how space situational awareness can be improved with better international collaboration. Next, Mr. Michael F. O'Brien provides a review of NASA's historical success with international cooperation. Mr. Richard D. Pino follows with a discussion on the growing importance of military satellite communications to the joint fight and highlights the international partnerships and resource sharing agreements with Wideband Global Satellite Communications and Advanced Extremely High Frequency as potential models for further expansion. Col Richard Boltz and Maj Zachary Owen expand upon and advocate a framework to conceptualize what is necessary to achieve international space situational awareness. They point to the lessons learned from Schriever V and the importance of the Joint Space Operations Center. Then, Col David Goldstein discusses the challenges associated with the independent pursuit of global navigation satellite systems by the European Union, Russia, Japan, India, and China. Col Craig Smith expounds upon the unique legal considerations associated with international space operations. And Lt Col Michael Gleason discusses the European Union's growth as a space power. He advocates for early US engagement to open the door for further collaboration in the future. Finally, Maj Jeffrey Bogar concludes the section with an article on the advancements India has made as a space power on the world stage.

In the "Industry Perspective" section, Mr. Jean-Yves Le Gall of Arianespace Évry-Courcouronnes, France describes the 30-year success of the French Guiana Space Center. Recognizing the importance access to space is to mission assurance, Mr. Le Gall highlights the center's payload processing and launch facilities for use as a national security space launch option. Mr. David McGlade, the chief executive officer of Intelsat, then describes how commercial partnerships could be better leveraged to meet our nation's growing demand for space communications bandwidth.

Under the "Historical Perspective" section, Dr. Rick Sturdevant, provides a historical synopsis of the development of international space efforts and cooperation. Dr. Sturdevant then concludes the journal with a review of *Counterspace: The Next Hours of World War III*, the second installment in a fictional series about space warfare.

I hope you find this edition of the *High Frontier Journal* beneficial. The next issue will focus on "Operationally Responsive Space," where we will consider the broad scope and potential, as well as the challenges and vision for the future. We have invited a diverse and distinguished group of experts to provide their insight.

General C. Robert "Bob" Kehler (BS, Education, Pennsylvania State University; MS, Public Administration, University of Oklahoma; MA, National Security and Strategic Studies, Naval War College, Newport, Rhode Island) is commander, Air Force Space Command (AFSPC), Peterson AFB, Colorado. He is responsible for organizing, equipping, training and maintaining mission-ready space, and cyberspace and capabilities for North American Aerospace Defense Command, US Strategic Command (USSTRATCOM), and other combatant commands around the world. General Kehler oversees Air Force network operations; manages a global network of satellite command and control, communications, missile warning and space launch facilities; and is responsible for space system development and acquisition. He leads more than 46,000 professionals, assigned to 88 locations worldwide and deployed to an additional 35 global locations.

General Kehler has commanded at the squadron, group, and twice at the wing level, and has a broad range of operational and command tours in ICBM operations, space launch, space operations, missile warning, and space control. The general has served on the AFSPC staff, Air Staff, and Joint Staff and served as the director of the National Security Space Office. Prior to assuming his current position, General Kehler was the deputy commander, USSTRATCOM, where he helped provide the president and secretary of defense with a broad range of strategic capabilities and options for the joint warfighter through several diverse mission areas, including space operations, integrated missile defense, computer network operations, and global strike.

Military International Space Cooperation

Mr. Richard W. McKinney
European Space Liaison
Office of the Undersecretary of the Air Force
Headquarters US Air Force, Washington, DC

The history of military international cooperation by the US is long. In fact, it began with the very beginnings of our republic when the French joined forces with the young US to fight the British in our war of independence. Today, we have joint military exercises (e.g., Red Flag), exchange officers at military academies, and exchange pilots with several nations (Germany, United Kingdom [UK], and France are three examples). However, we do not have the same level of cooperation regarding our space forces. While there are many reasons for this, the time may have come for a relook at our current level of international participation involving military space.

The US has enjoyed a level of capability in military space that, until recently, did not have many peers. During the Cold War, while the USSR did achieve a significant military capability, it could not match the depth and scope of the US effort. But this singular leadership is gradually changing as more nations achieve a capability for military space. To be clear, the US is still the world leader. What should also be added, though, is can and should the US leverage the growing capability in military space being put in place by our allies to enhance our own national security? If so, how should we go forward while protecting key information regarding our space forces?

One of the reasons why the US military has not taken greater advantage of the possibilities afforded by military international cooperation on space systems, is our military allies provided few, if any, space systems worthy of a cooperative effort. In order to cooperate, one would like to have a peer capability. Otherwise, neither partner will be able to gain the full benefit from cooperation. It would be perceived as a one way effort. There are situations where we offer military assistance and training that are clearly unidirectional. However, in the area of space because the level of entry in terms of knowledge, cost, and facilities is high, the circumstances have not encouraged international military space cooperation.

Because of this difference in capability, it may have kept us from thinking of how we might cooperate if and when our allies do develop a capability in military space. Yet, the military ability of our allies in space has increased tremendously in the last 5-10 years. The reasons for this growth in capability are many: industrial development, sovereignty, international traffic in arms regulations, technology advancements, realization of the ability of space systems, and so forth. The Helios, Skynet, Syracuse, SICRAL, SAR-Lupe, and COSMOS-SkyMed satellite systems are all examples of world class capability. If you examined each one and compared it to a counterpart capability in the US, you would find some less, some equal, and some more capable. But that is not the key point. We do not have total comparability on the air side either. The key point is that these systems exist and provide a very valuable capability. In Europe, agreements already exist for cooperation and exchange of data on the Helios, SAR-Lupe, and COSMOS-SkyMed systems between France, Germany, and Italy. And as time goes on, the experience gained from this cooperation can only increase the combined effectiveness of the European military space forces. It would also seem the US could benefit as well within the boundaries of protection of key information. Indeed there have been several initial steps towards cooperation with several international allies that are just at the beginning stages.

The other side of the cooperation issue is would our allies want to cooperate with the US on military space systems? I believe the answer to this is "yes." However, just as the US has concerns regarding cooperation, so do our allies. Three historical events illustrate the challenges associated with international cooperation. Two of the events illustrate just why our European allies might be more cautious to participate in cooperative efforts while the third, shows the benefits of an international collaboration.

Historical Event #1 - Launch

In the 1960s, there were only two countries that had the capacity to launch satellites, especially military satellites; the US and the USSR. Just as the world was more or less bi-polar in the political world, access to space was the same. The USSR achieved orbit on 4 October 1957 and the US followed with its first successful launch on 31 January 1958. The next country to achieve orbit with its own organic launch system was France in 1965. But France and the rest of Europe did not achieve a robust launch capability until 1979 when it launched the first Ariane 1 rocket. Since then the European Space Agency (ESA) has gone on to develop one of the world's best launch systems—the Ariane 5.[1]

In the 1960s it was another story. Europe did not have a reliable access to space or a large lift capability. In 1968 Europe asked, through National Aeronautics and Space Administration (NASA), the US to launch the Symphonie communications satellite. The decision on this request went on over many years and the reasons for the final outcome are complicated. But in the end, the US did not launch the European satellite. An excellent NASA history about this period summarizes it best: "The European decision to build Ariane had many roots and motives, among which was the unwillingness of the US to guarantee availability of launchers for operational communications satellites."[2] I have heard on more than one occasion that this failure to provide launch access was a key reason why Europe not only developed their own launch system, but is also why today, they continue to press for independence in space both in the civil and military areas across the space spectrum in areas such as communications, navigation, missile warning, environmental sensing, and intelligence, surveillance, and reconnaissance (ISR). Their

perception is that the US could not always be counted on to assist in the area of space. Ironically, it is this independent approach today that creates the situation where international cooperation is possible.

Historical Event #2 - Global Positioning System

In 1998, the European Commission adopted a plan for Europe to have full participation in worldwide Global Navigation Satellite Systems (GNSS).[3] To further this approach, the European Commission proposed to the US a plan to help develop and operate a joint system.[4] The strategy proposed two tracks. The first one, called GNSS-1, would be based on global positioning system (GPS) and Global Navigation Satellite System with overlays such as Wide Area Augmentation System and European Geostationary Navigation Overlay Service. The second track, GNSS-2, would be an internationally controlled system for civil use. This would include interoperable worldwide and regional systems among which was a fully independent European system. In order to achieve these objectives, Europe sought to "reach an agreement for acceptable joint GNSS." The conditions they looked to achieve were:

1. A full European Union role in the control of the system
2. A full European participation in its design and operation
3. A fair opportunity for European industry to compete in all aspects of the market

In the end, such a joint system was not achieved. Some of the conditions just stated were too hard to achieve. But the concept of cooperation was proposed and it showed a willingness to cooperate. As we all know now, Europe eventually undertook the development of the Galileo system. In the last six years, the US and Europe have cooperated very well in ensuring the GPS and Galileo signals are compatible and do not interfere with each other. Nonetheless, Galileo is a direct competitor to GPS. It will be a competitor in the civil market, and even though it was proposed to be used for civil systems only, it will surely be a competitor in the military arena as well. One could always speculate what the situation would be today if the decision on the European proposal was different. However, it does show that with the right protection in place, cooperation may serve a role in increasing our national security.

Historical Event #3 – Eagle Vision

In 1990, Air Force Maj James "Snake" Clark convinced the Office of the Secretary of Defense to sponsor an Air Force foreign comparative test to evaluate commercial satellite imagery to support mission planning systems. The French company Spot Image Corporation (Système Probatoire d'Observation de la Terre [SPOT]) had the only commercially available imaging satellite. They provided 222 image products to the US Air Force to evaluate if commercial imagery could be of value to the US military. The test was an outstanding success story, however, the imagery took five months to produce and deliver. It was apparent that unclassified, coalition releasable imagery was indeed valuable. The concern was that production and delivery took too long. The Gulf War began during the period of the test and prompted some major improvements.

On the second day of the Gulf War, the idea of a mobile commercial imagery direct downlink and processing unit was born. Again, the US Air Force turned to the French as they had the only known experience producing such a system. Eagle Vision 1 rolled out of the factory in late 1993 and was stationed at Ramstein AB, Germany. For the first time, fully processed commercial imagery could be available to the military users in hours rather than months.

Today the Eagle Vision system is used for international and domestic national security contingencies. A prime example of the capability of this system occurred during Hurricanes Katrina, Wilma, and Rita. The French SPOT Satellites 2, 4, and 5 provided 400,000 square kilometers (154,000 square miles) by direct downlink to Eagle Vision 4 in South Carolina.

Over the last 19 years, French-American cooperation produced Department of Defense's only mobile commercial imagery direct downlink system—a system that has been deployed to or has responded to every major war contingency and natural disaster since 2000.

This last example shows the value of international cooperation and how it can be accomplished in a manner that enhances national security without putting any data or information at risk.

Given these examples, the next logical question is "Why cooperate?" If we do cooperate, what are the things to keep in mind on how to proceed? Finally, what are the keys to success?

Figure 1. First Eagle Vision sitting next to an Air Force E-3 Sentry.

Why Cooperate?

Mutual Security

When you look at the reasons for having international space cooperation, the first and foremost reason to consider is mutual security. If the proposed cooperation does not enhance mutual security, then the reasons for going forward must have an overwhelming impact in other areas. I emphasize mutual because in cooperation, it should not just be a one way street. There should be a benefit for all parties. Rule number one in any potential cooperation should be the enhancement of national security. If this cannot be achieved, then the reasons for going forward become much less credible.

Training

In order to achieve the full benefit from any system, training is essential. It was not so long ago that many of our space systems were so classified that only a handful of people knew they existed and what their capabilities were. It was only when the curtain was lifted that our ability to exploit space for national security came into its own. The same is true today. In order to fully exploit the benefit to mutual security, you must train with the systems so they become part and parcel of your everyday activities. If you do not train, then when you need to use the asset, its effectiveness will be reduced. It takes time and dedicated resources to train. An excellent example is Red Flag. Thousands of people from nations around the world participate in this exercise. During Red Flags, in July and August 2008, units from NATO, Sweden, Turkey, Brazil, South Korea, India, and France all participated. It is a huge commitment in terms of people, equipment, time, and money. Yet we participate many (normally around 6-7) times every year. The training achieved is essential, not only for the employment of our own systems, but how we plan to cooperate with our friends and allies. The same benefits, I believe, could be obtained with our space systems.

Synergistic Effects

We have heard the saying: "The whole is greater than the sum of the parts." Using cooperative systems that were independently developed may in fact turn out to be better together than apart. Then again, we may find out that they are not compatible at all. Either way—it is better to learn this in a training environment than when required during an actual crisis or event.

Back-up Capability

One of the "truths" up until last year was that space was an uncontested arena. This all changed on 11 January 2007 with the shoot down of their own satellite by the Chinese. While this may not show intent, it certainly shows ability. Would it ever be the case that we would want a back-up capability due to loss of a system no matter the cause? If the answer is "yes," then it would only make sense that we at least plan for the potential exercise of such a capability.

The areas that might be available for back up include: communications, launch, space situational awareness, and ISR capabilities. All of these could be affected in some way by either natural causes (for instance, Hurricane Katrina eliminating a ground site) or by an overt act. Exercising or planning for a backup capability provided through cooperative efforts could have important benefits.

Space Economy

One of the most compelling reasons for space cooperation involves what I call the space economy. According to a 2007 Organisation for Economic Co-operation and Development study, the replacement cost of the worldwide on-orbit satellites could be as much as $230 billion.[5] The Space Foundation has reported that the global space revenues from space systems was $186.3 billion in 2006.[6] An economic impact of this magnitude is well worth protecting. Cooperation among space faring nations to ensure such free and open access is essential and necessary to maintain the level of service and capability we all enjoy today.

How to Proceed?

Because of the complexities that are inherent in international cooperation there are three key guidelines that I believe should be followed in initiating a cooperative effort:

1. Begin using areas of existing capability
2. Do not exchange funds
3. Use "in-kind" exchange

In order for cooperation to be a mutual benefit, the cooperative efforts should be more on a peer to peer basis rather than on a teacher—student relationship. This means the first efforts should be in areas that already exist and not a future projected capability.

NASA has the most experience in the US in international space cooperation. They have been doing this since around 1964. One of their rules is never exchange funds. There are a number of reasons for this but the main one is to let each country deal with their own internal funding needs. This allows each country to determine the best way to fund an effort. This also means that only "in-kind" exchanges are used. This means each country provides the people, equipment, and funding needed. A good example of this is the James Webb Telescope. NASA and ESA are cooperating on this program. One of the agreements is that ESA provides the launch vehicle and no funding from the US goes to the purchase of the launch. In turn, ESA gets increased access to the use of the telescope.

Keys to Success

In order for any cooperative effort for military space to succeed, there are six keys to success:

1. Political support
2. Personnel resources
3. Funding support
4. Program management
5. Be of mutual benefit
6. Protection of key data and information

Political support is required due to the simple fact that international sovereign countries are involved. There are many potential impacts to international cooperative efforts. Having the backing of the respective governments is the first key to success.

Secondly, each country needs to dedicate personnel resources to the effort. This should not be an ad hoc or temporary effort.

To be successful, a long term commitment is required. This leads to the next key, funding. Having the necessary money needed to work the myriad of issues that will arise during a cooperative effort and to procure the necessary equipment, pay for the required personnel, and pay for the overall integration effort.

A dedicated office or program management office will be needed. Not having a central point of contact for the cooperative effort will lead to confusion and eventually, failure.

The fifth factor is that the effort must be of mutual benefit. As mentioned earlier, without this, there will be no incentive to begin the effort in the first place.

Probably the most difficult key to success is the ability to protect key data and information. Some information should never be shared. Other information is essentially on the world stage (such as weather data). One of the great successes in international cooperation is in the area of weather. The US and Europe have agreements in place to share a wide range of weather information. But, as a senior European general once said at an international symposium, "The toughest thing to share is information." He said this in the context of sharing information among a nation's military branches internally. If sharing internal information to a country is difficult, it will be even more difficult to share internationally. But there can be a middle ground. Not all information needs to be shared but can be selectively chosen so that key benefits are achieved.

Potential Areas of Cooperation in Military Space

With the above guidelines on how to proceed and the keys to success, the next step is to determine what areas might be available for cooperation in military space.

The following is a list of what are suggested to be considered for cooperation:

1. Communications
2. Space surveillance
3. Operationally responsive space
4. Weather
5. Exercises or wargames
6. Imaging
7. Launch

A case can be made for each of these areas. But I would argue that it is the area of space surveillance and exercises that would hold the most immediate benefit and could be implemented very quickly. The increase in space debris and the potential impact on the space economy and military systems argues for such an approach. Just sharing the location of existing non-military assets would allow the space surveillance systems currently in use to concentrate their efforts on the location of unknown and military important objects. A process to protect sensitive and critical information needs to be in place but this can be solvable.

Another area that has promise is in the area of exercises or war games. Examining the techniques, tactics, and procedures on the ways to use assets is of tremendous importance. However, it is just as important to learn the impact of not having the availability of critical space assets. Space exercises such as the Schriever series of war games allow such analysis to occur. By including the assets of our allies in this game, it will greatly affect the outcome and lead to new discoveries in our knowledge on how to employ space assets. Yes, security issues need to be worked, but these are not insurmountable.

We are already showing how the use of commercial imagery with the Eagle Vision system can be a tremendous assistance. It also shows that international cooperation can be done on the commercial level and not just with the traditional military systems.

Conclusions

The ability to cooperate in exercises and the employment of air, land, and sea assets has long been a hallmark of US forces. The same advantages can accrue to space assets. We must proceed carefully so that we protect critical information, but also understand that through military space international cooperation our national security has the potential to be increased. It is a process that is worth the time to consider and to discover those areas of merit. It will take time and talent to do so but it is a journey worth undertaking.

Notes:

[1] Between 1965 and 1975, France made 12 launch attempts of their first rocket, the Diamant. Nine of the 12 were successful. It was used to put Astérix, the first French satellite, into orbit on 26 November 1965. Three successive versions of the Diamant rocket were developed, designated A, B, and BP4. All versions had three stages and a payload of approximately 150kg for a 200km orbit.

[2] Lorenza Sebesta, "SP-4217 Beyond the Ionosphere," NASA History Division web site, http://history.nasa.gov/SP-4217/ch11.htm.

[3] Communication (COM(98)29, 21 January 1998, European Commission.

[4] Letter to US Department of State, 12 May 1998, from Directorate General I – External Relations and Directorate General VII – Transport of the European Commission.

[5] "The Space Economy at a Glance," OEDC publishing, 2007.

[6] "The Space Report," Space Foundation, 2007.

Mr. Richard W. McKinney (BA, Business Administration, Washington State University, Pullman; MA, Business Administration, University of Montana, Missoula; BS, Electrical Engineering, Air Force Institute of Technology) is a member of the Senior Executive Service, is special assistant to the administrative assistant to the secretary of the Air Force, Headquarters US Air Force, Washington, DC. He is responsible for the review of the headquarters management of space responsibilities.

Mr. McKinney is a 1973 distinguished graduate of the Air Force ROTC program. He served 28 years on active duty, retiring as a colonel in May 2001. Mr. McKinney is certified level three in the acquisition areas of program management, acquisition logistics, and systems planning, research, development, and engineering. He was the first program director of the Evolved Expendable Launch Vehicle Program. Mr. McKinney was appointed to the Senior Executive Service in 2002. Prior to assuming his current position, he served as the Air Force liaison to Europe to facilitate and expand the Air Force international cooperation on space with Europe.

Coalition Space Operations – A NATO Perspective

Air Commodore Jan A. H. van Hoof
Royal Netherlands Air Force
Assistant Director Capabilities
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The North Atlantic Treaty Organization (NATO) led International Security Assistance Force (ISAF) in Afghanistan is driving many changes in NATO. The alliance is transforming itself to face new challenges in the ever evolving international security environment. Faced with limited resources, tenuous political commitments, and the complexities of operations on the ground in Afghanistan, NATO must optimally use all available capabilities and break new ground for increased cooperation and sharing of information. As we understand, the US has realized for some years now, how important space capabilities are and how dependent it has become on them. NATO is just coming to this same conclusion. As recently as two years ago NATO would not have been discussing space on a strategic level, but that has changed. Our operational requirements in Afghanistan compel us to address space today, and not at some vague point in the future. It is the Joint Air Power Competence Centre's (JAPCC) opinion that it is long past time to address space operations in NATO. Many new nations are joining the space community, and there is growing interest in NATO on space issues. It is now the time to put space on the agenda in NATO, and we contend that a "people first" approach is required.

NATO command arrangements are such that they do not provide a central, strategic-level entity for the promotion of combined and joint air and space power interests. Air and space power expertise has been spread across the NATO command structure without any real organizational integration or collaboration. The JAPCC is a 'center of excellence' that was established in 2005 by 17 NATO nations. Our vision is to be NATO's recognized champion for the advocacy and transformation of joint air and space power. The JAPCC focuses its attention on the strategic and operational level, and is "independent" from NATO. We are outside the formal NATO command structure. As such, this article articulates the JAPCC's view, not a NATO 'approved' vision, but one that is finding approval amongst the nations and the NATO staff.

NATO was established with the North Atlantic Treaty in April of 1949. The North Atlantic Treaty states that the nations '*… are determined to safeguard the freedom, common heritage and civilization of their peoples, founded on the principles of democracy, individual liberty, and the rule of law. They seek to promote stability and well-being in the North Atlantic area. They are resolved to unite their efforts for collective defense and for the preservation of peace and security*.'[1] NATO has successfully ensured the freedom of its members and prevented war in Europe during the 40 years of the Cold War. By combining defense with dialogue, it played an indispensable role in bringing east-west confrontation to a peaceful end. NATO provides a forum in which the nations can consult together on security issues of common concern and take joint action in addressing them. As such, many military capabilities were developed during the Cold War. Key among them were satellites. In fact NATO has been in the space business for quite some time. The first of the NATO series of communication satellites was launched on 20 March 1970.[2]

Figure 1. NATO rocket, launched from Cape Canaveral, Florida.

NATO Today

The alliance has grown quite a bit since the first 12 nations signed the North Atlantic Treaty. NATO is an alliance of 28 countries from North America and Europe, committed to fulfilling the goals of the North Atlantic Treaty.[3] Its foundation rests with four simple principles: solidarity, freedom, security, and the trans-Atlantic link. The role of NATO is to safeguard the freedom and security of its member countries by political and military means. NATO safeguards the allies' common values of democracy, individual liberty, the rule of law, and the peaceful resolution of disputes. It embodies the transatlantic link by which the security of North America and Europe are permanently tied together in support of their common interests.

Furthermore, dialogue and cooperation with non-NATO countries are helping to overcome the divisions of the Cold War era and to extend security and stability well beyond NATO borders. NATO structures and mechanisms provide the framework for cooperation with partner countries, which forms an integral part of the day-to-day activity of the alliance. Some of the partnerships include: Partnership for Peace nations (22), Mediterranean Dialogue nations (7), Istanbul Cooperation Initiative nations (4) and the NATO-Russia Council. NATO has significant international political and military influence. As we look to improve partnerships and cooperation in space, we should consider that with NATO, a significant amount of work has already been done to establish strong links between all of these nations.

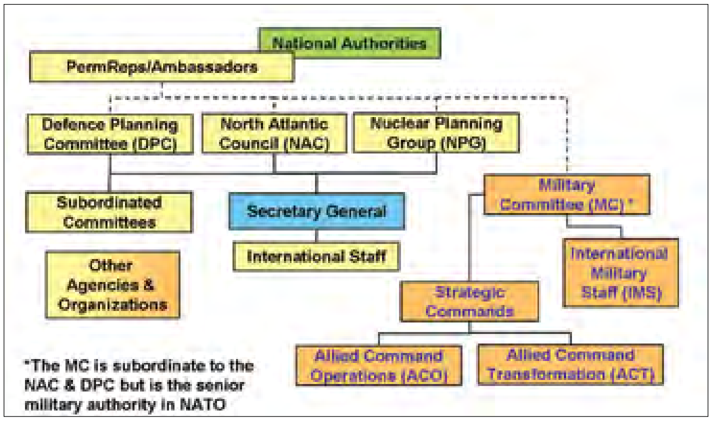

Figure 2. NATO Civil and Military Structure.

Obviously, with the breadth of interests and number of nations involved, it can become quite a complex organization, and for those that have not worked in NATO, it may seem nearly impossible to determine who is responsible for what. Figure 2 shows a very simplified organizational structure for NATO. Further details on the structure can be found on the NATO web page.[4] There are several key points to bear in mind about NATO. First, it is an alliance of *nations*. The 28 member countries retain their full sovereignty. Second, all NATO decisions are taken jointly by the member countries on the basis of consensus. While this is often difficult, once a decision has been agreed upon, it is a very powerful political and diplomatic tool.

The organizations highlighted in yellow are predominately civilian, those in orange, military. NATO's most important decision-making body is the North Atlantic Council. It brings together representatives from all the nations at the level of ambassadors, ministers, or heads of state and government. NATO's military structure is a multinational force planning organization and command system. It provides for joint planning, training, exercising, and operations, under the command of NATO's strategic commanders (Allied Command Transformation [ACT] headquartered in Norfolk, Virginia, and Allied Command Operations headquartered in Mons, Belgium). There are numerous committees, boards, working groups, and teams for most mission areas. The nations provide representatives to these groups.

Regrettably, we do not have committees, boards, groups, or teams dedicated to space. Very recently however, the international military staff has written a 'food for thought' paper and it looks like we may finally get space as a Military Committee (MC) agenda item. As we consider what NATO's role should be in space, it is important to look at fundamental reasons for the alliance, as written in the North Atlantic Treaty. Of the 14 Articles,[5] there are a few key points to highlight:

> **Article 2:** The parties will contribute toward the further development of peaceful and friendly international relations by strengthening their free institutions, by bringing about a better understanding of the principles upon which these institutions are founded, and by *promoting conditions of stability and well-being*. They will seek to eliminate conflict in their international economic policies and will encourage economic collaboration between any or all of them.
>
> **Article 4:** The parties will consult together whenever, in the opinion of any of them, the *territorial integrity, political independence, or security of any of the parties is threatened.*
>
> **Article 5:** The parties agree that *an armed attack against one* or more of them in Europe or North America shall be *considered an attack against them all* and consequently they agree that, if such an armed attack occurs, each of them, in exercise of the right of individual or collective self-defense recognized by Article 51 of the Charter of the United Nations, will assist the party or parties so attacked by taking forthwith, individually and in concert with the other parties, such action as it deems necessary, including the use of armed force, to restore and maintain the security of the North Atlantic area …
>
> **Article 6:** For the purpose of Article 5, an armed attack on one or more of the parties is deemed to include an armed attack:
>
> - On the territory of any of the parties in Europe or North America, on the Algerian Departments of France (2), on the territory of or on the islands under the jurisdiction of any of the parties in the North Atlantic area north of the Tropic of Cancer;
> - *On the forces, vessels, or aircraft of any of the parties, when in or over these territories* or any other area in Europe in which occupation forces of any of the parties were stationed on the date when the treaty entered into force or the Mediterranean Sea or the North Atlantic area north of the Tropic of Cancer.

Article 2 states that the alliance was established to promote the conditions of stability and well being. Space capabilities have and will continue to contribute to stability and well being. Article 4 states that if the territorial integrity, political independence, or security of any of the parties is threatened, that the nations may take action. The question that needs to be asked is that if a member nations' space system is attacked how would NATO or the nations respond? This leads us to the issue of Article 5. NATO is committed to defending its member states against aggression and to the principle that an attack against one or several members would be considered as an attack against all. So if a satellite or space system is attacked, at what trigger point would the security of a nation, or of the alliance be threatened enough to invoke Article 5? Lastly, Article 6 states that for the purpose of Article 5, an armed attack includes the forces, vessels, or aircraft of any of the parties, when in or over these territories. In 1949, there were no satellites, but clearly this language implies that it would include satellites or other celestial bodies. These articles are just as relevant today to the security of the space environment as they were to the air, land, and sea domains 65 years ago.

The 20th century proved that you must have control of the air. The 21st century will prove that you must have control in space. ~ Col Daniel Lewandowski, JAPCC, 2008

Current NATO Operations

NATO is an active and leading contributor to peace and security on the international stage. With these contributions, the alliance demonstrates both its willingness to act as a positive force for change as its capacity to meet the security challenges of the 21st century. Since its first military intervention in 1995, NATO has been engaged in an increasingly diverse array of operations. Today, roughly 70,000 military personnel are engaged in NATO missions around the world, successfully managing complex ground, air, and naval operations in all types of environments. These forces are currently operating in Afghanistan, Kosovo, Iraq, the Mediterranean, off the Horn of Africa, and in Somalia.

NATO's operation in Afghanistan currently constitutes the alliance's most significant operational commitment to date. Established by a United Nation mandate in 2001, the International Security Assistance Force (ISAF) has been under NATO leadership since August 2003. ISAF currently comprises some 64,500 troops (and the number continues to grow) from 42 different countries deployed throughout Afghanistan.[6] Its mission is to extend the authority of the Afghan central government in order to create an environment conducive to the functioning of democratic institutions and the establishment of the rule of law. While Afghanistan remains NATO's primary operational theatre, the alliance has not faltered on its other commitments, particularly in the Balkans. Today, there are almost 14,000 allied troops operating in the Balkans as part of NATO's Kosovo Force.

NATO does not just operate on the land. Operation Ocean Shield is focusing on at-sea counter-piracy operations off the Horn of Africa. Approved on 17 August 2009 by the North Atlantic Council, this operation is contributing to international efforts to combat piracy in the area. It is also offering, to regional states that request it, assistance in developing their own capacity to combat piracy activities. This just hits the highlights of some of NATO's many operational requirements. Against this operational background, the JAPCC looked into how space was supporting operations.

NATO Space Operations Assessment

Key findings:

- Need an holistic approach.
- Need to establish governance.
- Need to develop space expertise.
- Need to establish a space office.

Mission areas to be addressed:

- Combined space operations.
- Space situational awareness.
- Assuring the space domain.

NATO Space Operations Assessment

ACT requested in October 2007 that the JAPCC provide an assessment of NATO space operations, identifying gaps and recommendations on the way ahead for both the short and the longer term. In response, the JAPCC delivered a "NATO Space Operations Assessment" to ACT at the end of May 2008. This assessment was subsequently revised and published in January of 2009.[7] The assessment provides 23 recommendations, based on a number of identified gaps.

Space touches nearly all of our mission areas and supports all of the components. Therefore, a holistic approach is required. Thus far, there has been very little guidance or governance on space in NATO. You will not find a space policy, strategy, or road map. You will not find tactics, techniques, and procedures or space doctrine. We believe one of the reasons has been the lack of personnel with space expertise. This must be corrected with high priority. These issues led the JAPCC to develop the concept for a NATO space office to provide advice and strategic oversight for space matters in the alliance.

Furthermore, NATO is faced with three new potential mission areas. We must better integrate commercial, civil, and national space capabilities, or what we call, coalition space operations. Additionally, in order to protect against threats, mitigate risks and respond to attacks, we must have space situational awareness. Several nations are working on developing this capability. Thirdly, the alliance must decide if and how it will assure access to the space domain.

NATO is in the space business in two senses—it needs space to conduct its missions and its members have a vested interest in its continued availability. It is time, therefore, that the alliance addresses this domain in a similar way to how it has addressed land, sea, and air. As with most mission areas in NATO, we are challenged to deliver, and can only benefit from better integration and use of national capabilities. Space is no different to the other environments—we have capabilities that our war fighters could use today, if only we can get access to them and set up the processes and relationships to use them effectively. The JAPCC is

not necessarily advocating procurement of more NATO owned systems: the crux lies in the integrated and effective use of existing systems.

Allied Space Capabilities

Figure 3 clearly shows the growing international involvement in space—the advantages and potential of space are certainly not lost on the rest of the world. There are 15 NATO nations operating satellites and this number will continue to grow in the next couple of years. The European Union (EU) member nations have focused on safe and responsible use of space, primarily led by the European Space Agency (ESA).

Nation	Satellite Mission		
	Science	Telecom	ISR
Canada	✓	✓	✓
Czech Rep.	✓		
Denmark	✓		
France	✓	✓	✓
Germany	✓	✓	✓
Greece		✓	
Italy	✓	✓	✓
Luxembourg		✓	
Netherlands	✓		
Norway		✓	
Portugal		✓	
Spain	✓	✓	
Turkey		✓	
United Kingdom	✓	✓	✓
United States	✓	✓	✓

Figure 3. Satellite Mission Table.

The Europeans have been making great strides forward in recent years. In 2007, an EU space policy was established. Many European nations are partnering to develop Galileo and an Earth observation system called GMES. Additionally, ESA studies are also underway to develop a European space surveillance network.

In the past, just a few European nations were flying intelligence, surveillance, and reconnaissance (ISR) satellites. Every year this number continues to grow. Significant search and rescue capability has been added in the last couple of years. The MUSIS system has six partner nations and is defining what a future European imagery intelligence (IMINT) architecture might be. Unfortunately, the nations have not developed a coordinated European solution to space-based ISR. Each nation is pursuing its own interests and programs. NATO has operational requirements for space IMINT, but we do not believe this has been adequately captured in the current defense capabilities requirements documents. NATO has done this for other mission areas: space should be no different. Today, there are many systems available to us, both national and commercial. The challenge is to integrate what is already on orbit. To that end, the JAPCC envisions the need for a small space operations coordination center to integrate these many space capabilities. Significant capability could be delivered to our decision makers and warfighters if we were to put the issue on the agenda. It is time that NATO considers conducting combined space operations (CSO).

Key Space Issues

While CSO could significantly increase the available space support to the warfighter, we must also have assured access to those space-based services. Degradation or denial of these services will have a direct impact on our collective warfighting capabilities. One major threat is space debris. The number of objects being tracked in space continues to grow. As the risk of collisions with other orbiting objects increases, it is the responsibility of ***all*** space-faring nations to be responsible and minimize the creation of space debris. While there are many on-going dialogues, NATO has not joined in the effort to mitigate space debris or ensure flight safety. Thinking back on the North Atlantic Treaty articles highlighted earlier, is space debris a factor in peace and security? Does it threaten the assets of member nations? We think it does. The threats are real and NATO has yet to address them. And perhaps, what has not been considered yet: NATO might be a very good forum to address space debris and mitigate risk since NATO has a very robust command and control network at multiple security levels.

Let's further illustrate the point. Using the debris in low Earth orbit as an example, let's consider the threat and risk in key orbital altitudes, from 200 to 1,000 kilometers. On the following page, figure 5 on page 11 shows several collisions that have occurred since 1990. This will probably continue to increase with time. Notice too, that they are in this key orbital area. Now, let's add the Chinese antisatellite weapon to the mix. What satellites are possibly at risk to this weapon? If we assume it was tested at its maximum envelope, and taking just a few satellites from different nations that we have already seen, clearly the International Space Station, US, German, French, Italian, and other satellites are at risk.

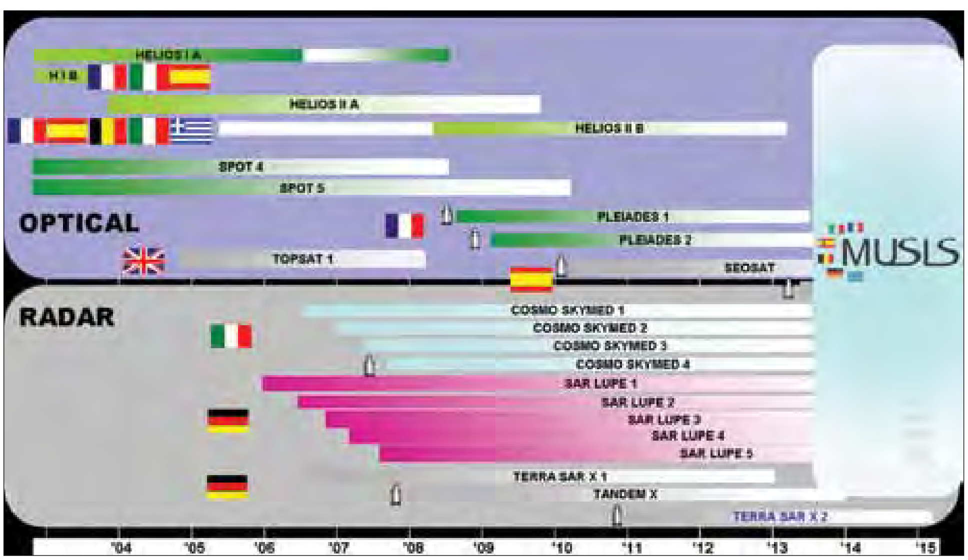

Figure 4. European Imagery Intelligence (IMINT).

The history of mankind has shown that wars will be fought wherever commerce and business interests are contested. As the commercial industry grows in space,

Not all of the nations are ready to move on space, but some are. There are numerous examples of like-minded nations working issues on behalf of the alliance.

it will become necessary to protect and defend those systems, especially as our reliance on them becomes more critical.

Putting it another way, would not our predecessors have considered it untenable to plan on free access to the skies without making any contingency for air defense or even the generation of an air picture? In order to protect against threats, mitigate risks, and respond to attacks, we would contend that space situational awareness is a must. Several nations are working on developing this capability, but the alliance also requires this space picture. The alliance must decide if and how it will assure its access to the space domain. This is a global security concern and NATO can be an important stakeholder.

As previously mentioned, other key issues are integration and personnel. Of high priority should be better integrating existing space capabilities from all the nations. There is a lot on orbit that we are not taking maximum advantage of. But it is the devil in the details; how do we task, process, and disseminate the information? How do we address disclosure issues? As we have already discussed, assuring the domain is vitally important. It requires close *partnership* between the nations. The US has many years of experience in space security and defense issues, with many challenges and issues to work through. NATO and most of the member nations are just beginning to think about space. However, technology will not be a large issue: much is available commercially. As NATO, at the moment, lacks governance and guidance, the alliance needs support from the nations to make it happen. The alliance also needs US experience and leadership to help us avoid mistakes and learn from US lessons in the Middle East and elsewhere. NATO does not have enough staff to adequately address space and this must be developed. NATO and the nations need 'people first' that know and understand the space business and can advise and work the issues.

The Road Ahead

The first step is for NATO and national leaders to understand what the key space issues are *and* to develop the will to address them. Education of senior leaders of the alliance is important. The JAPCC offers a few suggestions on how to address these issues. The JAPCC had already identified the need to develop a coalition space network and has been advising for the establishment of a NATO Space Operations Coordination Centre. This could be one node in a coalition network bringing together global space capability. Part of this coalition network must include a recognized space picture. We cannot make decisions if we do not know what is going on out there.

As already mentioned, NATO needs a space policy, strategy, road map, and other documents to address space at the tactical, operational, strategic, and political levels. In order to work space issues, there must be staff officers with space expertise. Not an army of space operators, but at least several positions in the command structure. These positions should be filled by those nations with a vested interest in space and that have the required experience and training (not just US personnel).

Furthermore, if we consider the potential of what small satellites offer NATO … the ability to increase the number of member nations in the space community and to provide needed ISR capability … we think that there needs to be a memorandum of understanding between like-minded nations to move forward on space. Not all of the nations are ready to move on space, but some are. There are numerous examples of like-minded nations working issues on behalf of the alliance. Programs such as the F-16, C-17, NATO Airborne Warning and Control System, missile defense, and others have demonstrated that a sub-set of like-minded NATO nations can accomplish a lot on behalf of the alliance.

What are the nations willing to put on the table? We know that space needs to be addressed. Having the *will* to address space will without doubt prove to be very transformational for NATO. NATO needs space capabilities and we think we all

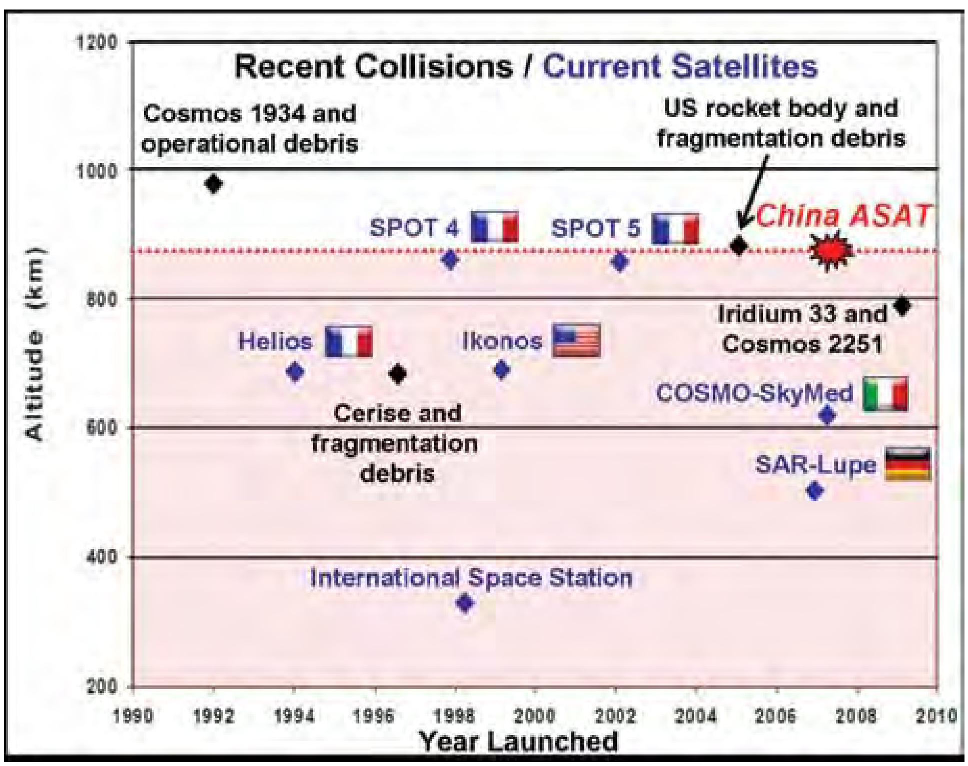

Figure 5. Recent Collisions and Current Satellites.

need NATO as a forum, politically and militarily. We should move forward together—this leads to some implications from the Schriever V Wargame that was held earlier this year.

NATO would likely respond to an attack on a member nation's space system. At what point is the 'redline' crossed? Destroying one or two satellites may not trigger a military response, but certainly NATO would be concerned. And in fact, it is our assertion that some nations would be gravely concerned and would demand to be involved in any sort of a space and cyber war as they pose significant stability and security risks to all the member nations. Nations such as France, Germany, Italy, and others with a significant investment in space assets would certainly be concerned. It should also not be lost that allied space assets are part of global space capability. What if US assets would cease to operate? Allied systems offer immediate reconstitution, flexibility, redundancy, and could even strengthen deterrence as an adversary may not want to invoke a NATO response with its 28 member nations.

Schriever 10 is quickly approaching and planning is already underway. As Air Force Space Command develops the event, we would like to emphasize that space is strategically important to NATO, the European nations, and other nations like India and Japan. It was not lost on the senior players at Schriever V that policy, rules of engagement, and other issues must be worked out well in advance. CSO starts with training and exercising together.

Closing Remarks

The JAPCC will continue its parallel, bottom-up, top-down approach. We are working to make a difference and better integrate existing space capabilities. At the same time, there are long term, political and strategic issues that must be addressed. At the strategic level, NATO should consider establishing a NATO space office and a space operations coordination center. The JAPCC will continue to inform and educate political and military leadership on space issues. At the operational and tactical level, as NATO begins to integrate space into education, training, and exercises, it is our hope that commanders will better understand space capabilities, vulnerabilities, and issues. NATO and the nations must establish staff positions and develop space expertise. A 'people first' approach is recommended in order to provide the advice and expertise to move forward.

We have only begun to develop space power for the alliance. There will be more to follow in the future. The JAPCC looks forward to continuing to support NATO and the nations and to leading the charge on developing space power for NATO. We put space on the table, and will be anxious to hear your response.

Notes:

[1] The North Atlantic Treaty Organization (NATO), Washington DC, 4 April 1949, http://www.nato.int/cps/en/natolive/official_texts_17120.htm.

[2] NATO Update, 1970, http://www.nato.int/docu/update/70-79/1970e.htm.

[3] Albania, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Iceland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Turkey, United Kingdom, and the US.

[4] NATO home page, www.nato.int.

[5] NATO, Washington DC, 4 April 1949, http://www.nato.int/cps/en/natolive/official_texts_17120.htm.

[6] International Security Assistance Force: Afghanistan, www.isaf.nato.int

[7] Joint Air Power Competence Centre, NATO Space Operations Assessment, January 2009, www.japcc.de.

The author wishes to acknowledge Lt Col Tom Single, air and space subject matter expert at the JAPCC, for contributing to this article.

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Improving Space Security through Enhanced International Cooperation

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Developing sustainable space security through enhanced international cooperation is a critical issue for the US and all spacefaring actors. The need to improve international space cooperation stems from the burgeoning importance of space, the growing number major foreign space actors, and the increasing efficacy of their space capabilities. In the past, when the US was a more dominant space actor, it sometimes made sense to go it alone. Today, as its relative spacepower declines, the US can bolster prospects for advancing sustainable space security by expanding international space cooperation and improving the effectiveness of these efforts. It is not a panacea, but improving international space cooperation can broaden and deepen the pool of responsible space stewards, make more efficient use of limited resources, and spotlight those actors who choose not to cooperate.

Unfortunately, pursuing better international space cooperation can too often be highly complex, time consuming, fraught with inconsistencies, and ultimately frustrating. This article attempts to equip space professionals to deal with some of these impediments by placing cooperation tensions and balances within a broader conceptual context; discussing some of the major current cooperation opportunities in areas such as space situational awareness (SSA), satellite communications (SATCOM); hosted payloads, and operationally responsive space (ORS) with friends and allies including Australia, Canada, the United Kingdom (UK), France, Germany, Japan, and India; and outlining cooperation opportunities and challenges with respect to the Russian Federation and the People's Republic of China.

Tensions and Balances for Space Cooperation

Prospects for effective space cooperation are shaped by a number of deeper and more fundamental tensions and balances. First, at the systemic level, there are tensions between unilateral versus multilateral or collective approaches to security and economics. Throughout history humans have struggled with fundamental questions about how best to provide security, as well as the best means to generate and distribute wealth. The need to preserve our biosphere through sustainable development presents additional fundamental tensions and balances. Various overarching approaches including tribalism, feudalism, capitalism, socialism, as well as alliances and international organizations have been used but it is unlikely that fundamental tensions and balances at the systemic level can be resolved anytime soon. Space capabilities can help balance and shape some of the tensions associated with security, economics, and ecology but they cannot transcend these fundamental issues. Space professionals need to understand that space capabilities are just one of a large number of factors shaping these fundamental issues and that they cannot, alone, determine how associated tensions should be balanced. Many concerns space professionals have with attempting to improve international space cooperation can be assuaged simply by keeping these fundamental tensions in mind and understanding the sometimes limited place of space issues within this broader context.

A second set of concerns about international space cooperation is primarily at the state and individual levels-of-analysis and focus on the tensions and balances between those attempting to generate wealth (merchants) and those responsible for security (guardians).[1] Major tensions and balances between merchants and guardians associated with international space cooperation include the desired degree of transparency versus secrecy and the proper balance between free trade and export controls. In general, merchants favor increased transparency and trade whereas guardians support more secrecy and export controls. Merchants point to the benefits of innovation, competitive advantages, and lower costs that can flow from free trade but guardians emphasize costs in lost intellectual property, proliferation, and decreased security that can stem from lax security and export controls. These tensions become manifest in many specific ways such as prospects for Chinese cooperation on the International Space Station and other human exploration initiatives, ongoing pressures for the US to loosen its space export controls, and the potential for major spacefaring actors to develop cooperative processes and a shared architecture to improve SSA. Space professionals need to keep tensions between merchants and guardians in mind when seeking ways to balance transparency versus secrecy, as well as free trade and export controls.

Due to the fundamental tensions and balances associated with international space cooperation at the systemic, state, and individual levels it is difficult to craft consistent, long-term space policies. These factors also help explain why space policy is seldom a standalone consideration or focuses on just one space sector. It is particularly difficult to reconcile desires to limit proliferation of ballistic missile technology to states of concern such as Iran with attempts to promote human spaceflight and policies designed to improve the competitiveness of US space exports. Despite these probably unavoidable inconsistencies, effective international space cooperation is needed now more than ever and space professionals need to be creative, patient, and tena-

cious in developing and improving cooperative space capabilities, yet also understand and support broader policy objectives.

Ongoing space policy reviews including a congressionally-directed Space Posture Review and Presidential Study Directives on US National space policy are likely to encourage policies that are more supportive of pursuing transparency- and confidence-building measures (TCBM), as well as greater reliance on commercial and international partners.[2] Consideration is also being given to the best ways any new approach can usefully build from fundamental goals in the 2006 US National space policy to "oppose the development of new legal regimes or other restrictions that seek to prohibit or limit US access to or use of space" while also encouraging "international cooperation with foreign nations and/or consortia on space activities that are of mutual benefit."[3] The US can expect that it will continue to make the best progress in developing effective, sustainable, and cooperative approaches to space security by building on the ongoing thoughtful dialogue between all major space actors in several venues that emphasizes a number of primarily incremental, pragmatic, technical, and bottom-up steps. Prime examples of this approach include the February 2008 adoption by the United Nations General Assembly of the Inter-Agency Debris Committee voluntary guidelines for mitigating space debris and the December 2008 release from the Council of the European Union of a draft code of conduct for outer space activities.[4] A key challenge for all major spacefaring actors is to leverage these and other ongoing processes and encourage bilateral, multilateral, and collective approaches to space cooperation that include non-state actors.

Opportunities for Enhanced Cooperation with Friends and Allies

The US DoD has been engaging in international cooperation since the earliest days of the military space program. Cooperation has included a number of our long-standing allies such as Australia, Canada, and the UK, as well as (in selective areas) with some countries that have not always been considered allies, such as the USSR. Cooperation has not only taken place with other countries, but also with international organizations, companies, and other consortium. As the DoD looks to the future of military space, international cooperation is likely to increase and take on a broader scope. This section attempts to highlight some of the issues associated with broader international cooperation and explore some of the paths for such cooperation.

When one considers international cooperation from a national security space perspective, the bookends are to either go it alone on the one hand (no cooperation) or to seek the fullest extent of integrated space operations that can be considered. While a "US-only" approach of going alone is clearly the most expensive solution, its appeal is total independence and freedom from the potential that an international partner will fail to uphold its commitments whether through change of political will or system failure. On the opposite end of the spectrum, total integration offers cost sharing, interoperability, and contributions from international partners which the US might otherwise not have developed alone, but with the price of dependence on such international partners. Although the DoD has developed and operated many organic military space capabilities, the trend has been to move in the direction of more international cooperation, not less. The challenge then is to find the right mix of a "US-only" independent capability along with an "inter-dependent" set of capabilities and with the right international partners.

As the numbers of countries, international companies, and organizations that operate space systems have increased, SSA has become the topic de jour. Understandably, anyone of these entities with a multi-million dollar investment in a space system is concerned about the safe passage of that system through space. Highlighted by the 2007 Chinese antisatellite weapon (ASAT) test and 2009 Iridium-Cosmos collision, debris has become a major source of concern for space operators. In the US, DoD has been given responsibility for SSA. A major contributor in DoD's SSA picture is DoD's space surveillance network, a global network of sensors that has involved cooperation for many years with a number of international partners including the UK, Canada, Denmark, and Norway. The European Union in cooperation with the European Space Agency is undertaking a study that is expected to recommend development of a European space surveillance system. France and Germany both have significant financial investments in space programs and their investments are only expected to increase. They both currently are operating space surveillance sensors that could be used to contribute to a European SSA system. As DoD capability grows, it makes sense to look for opportunities for cooperation with European partners including France and Germany.

Responsibility for the DoD's SSA picture belongs to Joint Functional Component Command for Space and its Joint Space Operation Center (JSpOC). Allied exchange officers from Australia, Canada, and the UK currently work at Vandenberg AFB, California in the JSpOC. The final report from the most recent Schriever V Wargame, which involved participants from Australia, Canada, and the UK, included recommendations to establish a standing combined joint task force for space with the partnership of key allies and expand the JSpOC to a Combined Space Operations Center. This concept explored in Schriever V would link allied space operations/coordination centers in a way that allows for sharing of data and traditional space control missions including space launch support, space object detection, tracking, and identification, satellite maneuver support and anomaly resolution, collision avoidance, and space object re-entry support. The challenge of such international cooperation is data sharing and governance within an international regime that also protects national security information. The solution will not be simple, but given the growing number of satellite owners/operators and the added value of international cooperation on SSA, it makes sense to work through the risks associated with cooperation.

Satellite communications is another area likely to see expanded space cooperation. The DoD's advanced extremely high frequency SATCOM system currently includes a partnership with Canada, the Netherlands, and UK. More recently DoD completed an agreement with Australia to partner in the Wideband Global SATCOM system. These partnerships allow for interoperability in communications systems, very vital to combined operations, in addition to the advantages that come with cost sharing. Given the Transformational Satellite Communications system program cancellation, DoD is considering

options to address future SATCOM needs and how to best meet requirements. Among the options are to increase the number of satellites in current programs and adding commercial leased SATCOM. Allied contributions could also be considered as a means of providing bandwidth.

Given the cost of building dedicated military satellites, DoD should assess the value of hosting DoD payloads on commercial buses and partnering with allies through the same means. Missions such as missile warning, environmental monitoring, and low-orders of space-based surveillance in addition to communications could all potentially be performed via a DoD payload hosted on a commercial bus. International cooperation could allow for an ally with limited funding to purchase a US sensor or develop its own sensor and operate in a contributing manner as part of a larger system. As "Google Earth" demonstrates, information derived from state-of-the-world sensors can be useful and is arguably more useful than state-of-the-art derived information if that information is neither available nor releasable.

Finally, the efforts of the ORS-Office (ORS-O) have real potential for international cooperation. The ORS-O's objectives are to develop enablers required to meet the nation's need for responsive space capabilities and execute rapid end-to-end efforts that address critical and urgent operational needs of joint force commanders. These enablers include affordable launch vehicles, standard plug-and-play platforms and payloads, telemetry, tracking, command and control, sensor tasking, data processing, exploitation, and dissemination among others. This list is ripe to look for opportunities for international cooperation, especially where the need can be satisfactorily met by commercial-off-the-shelf capabilities that are good enough to meet the warfighter's urgent requirement. While much of our cooperation is likely to be with our traditional allies: Australia, Canada, UK, and other European countries; the US should not overlook opportunities to cooperate with Asian allies such as Japan, India, and South Korea where it makes sense.

Prospects for Enhanced Space Cooperation with Russia and China

There are a number of long standing and complex challenges that must be addressed in order to improve space cooperation between the US and the Russian Federation. As the protagonists of the Cold War space race, Russia and the US have a long history of intense competition in space. However, even during the Cold War, they began to cooperate, although the 1975 "handshake in space" enabled by the Apollo-*Soyuz* Test Project proved to be the high water mark for superpower space cooperation. The end of the Cold War removed one important motivation for prestige-based civil space competition, but strengthened other incentives to pursue cooperative ventures such as the International Space Station (ISS). In building on the work of the Gore-Chernomyrdin Commission to bring the Russians aboard the ISS, the US was thinking not just about space cooperation but also had important counterproliferation objectives in employing Russian space scientists as major partners on the ISS effort and lessening their potential to contribute to the weapons market. In September 1993 Vice President Albert "Al" Gore announced that the Russian Federation would join the ISS effort and also abide by the terms of the Missile Technology Control Regime. The US paid Russia $400 million in its initial ISS contract, the same amount Russia claimed it had forgone by cancelling a contract with India for cryogenic rocket engine technology, and provided a total of $800 million in ISS funding to Russia between 1994-98.[5]

Unfortunately, however, it is not clear that bringing Russia aboard the ISS appreciably slowed its sale of weapons and dual-use technologies to states of concern such as Iran. In 1995, Russia signed an $800 million agreement with Iran to complete construction of the Bushehr nuclear reactor and in 1996 reports surfaced accusing Russia of providing significant and comprehensive assistance to Iranian ballistic missile development programs.[6] Congress responded with several approaches that sanctioned the Russians and eventually passed the Iran Nonproliferation Act (INA), a bill signed into law in March 2000 that allowed sanctions but did not make them mandatory as in previous legislation. Section 6 of the INA:

> Prohibits the US government from making payments in connection with ISS to the Russian space agency, organizations, or entities under its control, or any other element of the Russian government, after 1 January 1999, unless the president makes a determination that Russia's policy is to oppose proliferation to Iran, that Russia is demonstrating a sustained commitment to seek out and prevent the transfer of WMD [weapons of mass destruction] and missile systems to Iran, and that neither the Russian space agency nor any entity reporting to it has made such transfers for at least one year prior to such determination.[7]

No president has yet made a determination that Russia has a sustained commitment to oppose proliferation to Iran but in 2005 and 2008 the provisions of the INA were amended to allow the National Aeronautics and Space Administration (NASA) an ISS exemption that now extends through 1 July 2016.[8] This exemption has been critical in maintaining the schedule for completing construction of the ISS, especially as NASA became increasingly dependent on Russia for astronaut safety and transportation following the 2001 cancellation of the US crew return vehicle in favor of a *Soyuz* lifeboat and the stand down of the Shuttle fleet between February 2003 and July 2005 after the *Columbia* accident. With the price of Russian transportation to the ISS rising to $51 million per astronaut beginning in 2012,[9] no clear abatement of Russian technology exports or strong support for more stringent UN sanctions on Iran, and current US indecision on whether and when it will deploy its next human space launch capabilities, the space cooperation experience with Russia illustrates just how difficult it can be to reconcile space cooperation and counterproliferation objectives.

China presents the US with both the greatest opportunities and the most difficult challenges for space cooperation. In October 2003, China independently launched and recovered its first taikonaut, or astronaut, becoming just the third member of an elite spacefaring club with Russia and the US. Then in January 2007 China first successfully tested a kinetic energy ASAT and again joined Russia and the US as one of only three states known to have demonstrated this capability. China's growing power and space emphasis may become manifest in mostly peaceful and cooperative ways or may lead to increasing competition and perhaps even conflict with the US. If the US can successfully

engage China in effective space cooperation it may reduce the risks of increasing competition but it must avoid the mistake of treating China like the Soviet Union or seeing this relationship through the lens of the Cold War. The Soviet Union was only a military superpower, whereas China is a major US trading partner and an economic superpower that recently passed Germany to become the world's third largest economy and is poised to pass Japan soon, and is on a path to become larger than the US economy, perhaps within 10 years. Because of its economic muscle, China can afford to devote commensurately more resources to its military capabilities and will play a more significant role in shaping the global economic system. For example, China holds an estimated $1.4 trillion in foreign assets (mainly US treasury notes), an amount that gives it great leverage in the structure of the system.[10]

Like many other major spacefaring states around the world, China does not make clear distinctions between its civil and military space activities, pursuing instead many advanced and dual-use capabilities with military applications, sometimes even with foreign partners such as on the China-Brazil Earth Resources Satellite program. Leveraging its latecomer advantage during its 10th (2001-05) and 11th (2006-10) Five Year Plans,[11] China has moved more quickly in developing a wider range of military space capabilities than any previous spacefaring state and today has deployed comprehensive space systems that are less capable but parallel those of the US in all mission areas except for space-based missile launch detection.

China's civil space effort began in earnest in the post-Cold War era; it pursued human spaceflight and exploration for prestige and set China apart as a great power. From the beginning, however, all Chinese space activity, including its civil space activity, has been either directly or indirectly controlled by the People's Liberation Army (PLA). Although some Chinese civil space efforts began in the 1950s and the China National Space Agency (CNSA) was established in 1993, ostensibly to direct China's civil space program, under the current bureaucratic structure and for "most of its existence CNSA was embedded within the Commission for Science, Technology, and Industry for National Defense, a higher ministerial entity that oversaw many of China's defense industries."[12] Moreover, CNSA appears to have little decision-making authority; its main function seems to be to interface with foreign space agencies, a role similar to that played by the Ministry of Defense and other organizations within the Chinese government that present this type of façade as the way the outside world is to interact with the Middle Kingdom but can cause problems in correctly aligning counterpart organizations and decision-making structures.

Now that it has achieved its major initial prestige goals, China may become more interested in partnering on cooperative civil space efforts such as the ISS or other joint projects to pursue the ambitious exploration goals it has espoused, including a permanently inhabited space station and a lunar landing by 2020. It is not clear, however, whether China will continue to pursue civil space objectives primarily unilaterally, or will work increasingly with the very diverse members of the Asia-Pacific Space Cooperation Organization it has established,[13] or partner with other major space actors. If China is interested in pursuing cooperative civil space efforts with the US, it will need to make that more clear than it did to Michael Griffin in September 2006 when he made the first visit by a NASA administrator to China yet was granted only limited access to his counterpart space decision makers and other space personnel and facilities. The rhetoric during the October 2009 visit of the second-highest ranking PLA member, General Xu Caihou, vice chairman of the Chinese Central Military Commission, to a number of important US locations including the headquarters of US Strategic Command, as well as the dialogue between Presidents Hu Jintao and Barak Obama during Obama's November 2009 visit to Beijing, offer an opportunity to begin building cooperative space efforts and developing better space and security relationships.

An excellent opportunity to repair US-China commercial space relations would be to relax the International Traffic in Arms Regulations restrictions placed on China in the late 1990s by finding better ways to balance the conflicting objectives of developing mechanisms to keep dual-use technologies thought to be dangerous out of the wrong hands while promoting exports of benign commercial space technology. Congress and the Obama administration have begun to reevaluate current US export controls and should make it a priority to improve the competitiveness of US space exports by adjusting policies and regulations. The 2009 congressionally mandated National Academies of Science study provides many useful recommendations for rebalancing overall US export control priorities.[14] In addition, the US should implement key recommendations from the Center for Strategic and International Studies study on the space industrial base such as removing from the munitions list commercial communications satellite systems, dedicated subsystems, and components specifically designed for commercial use.[15]

The US also must consider how best to engage with the Chinese on a range of important ongoing TCBMs that will likely shape the future of US-China space cooperation. The history of top-down approaches to space arms control repeatedly has shown they are not likely to be the most fruitful ways to advance space security, a point strongly emphasized by Ambassador Donald Mahley in February 2008: "Since the 1970s, five consecutive US administrations have concluded it is impossible to achieve an effectively verifiable and militarily meaningful space arms control agreement."[16] Nonetheless, in ways that seem both shrewd and hypocritical, the Chinese are developing significant counterspace capabilities while simultaneously advancing various proposals in support of prevention of an arms race in outer space initiatives and pursuing the Chinese-Russian draft treaty on Prevention of Placement of Weapons in Outer Space (PPWT) introduced at the Conference on Disarmament in February 2008. For the PPWT in particular, while it goes to considerable lengths in attempting to define space, space objects, weapons in space, placement in space, and the use or threat of force, there are still very difficult and unclear issues with respect to how specific capabilities would be defined. An even more significant problem relates to all the terrestrial capabilities that are able to eliminate, damage, or disrupt normal function of objects in outer space such as the Chinese direct ascent ASAT. One must question the utility of an agreement that does not address the security implications of current space systems to support network enabled terrestrial

warfare, does not deal with dual-use space capabilities, seems to be focused on a class of weapons that does not exist or at least is not deployed in space, is silent about all the terrestrial capabilities that are able to produce weapons effects in space, and would not ban development and testing of space weapons, only their use.[17] Given these glaring weaknesses in the PPWT it seems plausible that it is designed as much to continue political pressure on the US and derail US missile defense efforts as it is to promote sustainable space security.

Other specific Sino-American cooperative space ventures or TCBMs that have been proposed and are worthy of further consideration include: inviting a taikonaut to fly on one of the remaining space shuttle missions and making repeated, specific, and public invitations for the Chinese to join the ISS program and other major cooperative international space efforts. The US and China could also work towards developing non-offensive defenses of the type advocated by Philip Baines.[18] Kevin Pollpeter explains how China and the US could cooperate in promoting the safety of human spaceflight and "coordinate space science missions to derive scientific benefits and to share costs. Coordinating space science missions with separately developed, but complementary space assets, removes the chance of sensitive technology transfer and allows the two countries to combine their resources to achieve the same effects as jointly developed missions."[19] Michael Pillsbury outlined six other areas where US experts could profitably exchange views with Chinese specialists in a dialogue about space weapons issues: "reducing Chinese misperceptions of US space policy, increasing Chinese transparency on space weapons, probing Chinese interest in verifiable agreements, multilateral versus bilateral approaches, economic consequences of use of space weapons, and reconsideration of US high-tech exports to China."[20]

Bruce MacDonald's report on China, Space Weapons, and US Security for the Council on Foreign Relations offers a number of noteworthy additional specific recommendations for both the US and China including: For the US—assessing the impact of different US and Chinese offensive space postures and policies through intensified analysis and "crisis games," in addition to wargames; evaluating the desirability of a "no first use" pledge for offensive counterspace weapons that have irreversible effects; pursuing selected offensive capabilities meeting important criteria—including effectiveness, reversible effects, and survivability—in a deterrence context to be able to negate adversary space capabilities on a temporary and reversible basis; refraining from further direct ascent ASAT tests and demonstrations as long as China does, unless there is a substantial risk to human health and safety from uncontrolled space object reentry; and entering negotiations on a [kinetic energy] KE-ASAT testing ban. MacDonald's recommendations for China include: providing more transparency into its military space programs; refraining from further direct ascent ASAT tests as long as the US does; establishing a senior national security coordinating body, equivalent to a Chinese National Security Council; strengthening its leadership's foreign policy understanding by increasing the international affairs training of senior officer candidates and establishing an international security affairs office within the PLA; providing a clear and credible policy and doctrinal context for its 2007 ASAT test and counterspace programs more generally and addressing foreign concerns over China's ASAT test; and offering to engage in dialogue with the US on mutual space concerns and becoming actively involved in discussions on establishing international space codes of conduct and confidence-building measures.[21]

Finally, Beijing and Washington should pursue specific initiatives to follow-up on the cooperative dialogue during the visits of General Xu Caihou and President Obama, as well as initiating discussions about recent statements by General Xu Qiliang, commander of the PLA Air Force (PLAAF), that a space arms race is inevitable and the PLAAF must develop offensive space operations.[22] President Hu quickly repudiated these statements but the two sides need to find a way to initiate and sustain focused discussions about the difficult space security issues raised by the general's statements since they represent an unprecedented level of public transparency on the part of the PLA, undoubtedly reflect the position of the PLA and other important stakeholders within the Chinese government, and represent an inherent part of the context for space security about which the US and China must develop better shared understanding. Counterintuitively, Beijing and Washington can lay a stronger foundation for sustainable space security through transparent dialogue over these most difficult issues rather than by trying to avoid them since more diplomatic approaches may assuage but cannot eliminate the growing strategic and military potential of space capabilities.

Notes:

[1] The role of warriors, merchants, and guardians is discussed in Plato's *Republic*. See Scott Pace, "Merchants and Guardians," in John M. Logsdon and Russell J. Acker, eds., *Merchants and Guardians: Balancing US Interests in Global Space Commerce*, (Washington: Space Policy Institute, George Washington University, May 1999).

[2] Section 913 of the Fiscal Year 2009 National Defense Authorization Act (PL 110-417) directs the Secretary of Defense and Director of National Intelligence to submit a Space Posture Review to Congress by 1 December 2009. In addition, the Obama Administration has ongoing Presidential Study Directives that are examining the need for changes to current National space policy; see Amy Klamper, "White House Orders Sweeping US Space Policy Review," *Space News*, 15 July 2009.

[3] "US National Space Policy," (Washington, DC: The White House, Office of Science and Technology Policy, 14 October 2006), 2.

[4] United Nations General Assembly Resolution 62/217, "International cooperation in the peaceful uses of outer space," (New York: UNGA, 1 February 2008) and Council of the European Union, "Council conclusions and draft Code of Conduct for Outer Space Activity, (Brussels: Council of the European Union, 3 December 2008).

[5] Sharon Squassoni and Marcia S. Smith, "The Iran Nonproliferation Act and the International Space Station: Issues and Options," (Washington, DC: Congressional Research Service, 22 August 2005), CRS-2-3.

[6] Ibid.

[7] Ibid.

[8] Carl Behrens and Mary Beth Nikitin, "Extending NASA's Exemption from the Iran, North Korea, and Syria Nonproliferation Act," (Washington, DC: Congressional Research Service, 1 October 2008), CRS-5-6. The sanctions were expanded in 2005-06 and the INA became the Iran, North Korea, Syria, Nonproliferation Act.

[9] Austin Modine, "Russia Raises Fare for NASA's Soyuz Rocket Rides, *The Register*, 13 May 2009, online blog, http://www.theregister.co.uk/2009/05/13/russia_raises_rocket_fare/, 12 December 2009.

[10] James Fallows, "The $1.4 Trillion Question," *The Atlantic*, January/February 2008.

[11] Parts of China's space goals for its 10th and 11th Five Year Plans were announced publicly; see Kevin Pollpeter, *Building for the Future: China's Progress in Space Technology During the Tenth 5-Year Plan and the US Response*, (Carlisle: Strategic Studies Institute, US Army War College, March 2008), 3-5 and 19-22.

[12] Dean Cheng, "Beginning the Journey of a Thousand Miles? Prospects and Pitfalls of US-China Space Cooperation," *The Space Review*, 23 March 2009. Cheng explains that COSTIND "was downgraded in a March 2008 Chinese governmental reorganization, which saw many parts of the space bureaucracy subsumed under, after several iterations, what is now called the Ministry of Industry and Information Technology. Yet, there has yet been little indication of whether CNSA remains subordinate to this lower entity (the State Administration for Science, Technology, and Industry for National Defense or SASTIND), is its bureaucratic equivalent, or is now independent of the military-industrial bureaucracy. More troubling is the lack of explanation on how CNSA relates to the PLA, and specifically the General Armaments Department (GAD)—one of the four General Departments that manages the PLA. The GAD is apparently responsible for managing all of China's space infrastructure, i.e., its launch facilities and mission control centers. It will also, according to press reports, be responsible for the new Chinese space lab (the Tiangong). Yet, despite its importance, the GAD is rarely mentioned in official Chinese documents on their space program." Downloaded from http://www.thespacereview.com/article/1335/1, 18 June 2009.

[13] APSCO is headquartered in Beijing and began formal operations in December 2008. China, Bangladesh, Iran, Mongolia, Pakistan, Peru, and Thailand are member states and Indonesia and Turkey also signed the APSCO convention

[14] National Research Council, Beyond *"Fortress America:" National Security Controls on Science and Technology in a Globalized World* (Washington: National Academies Press, 2009). With the new administration and Congress as well as former Congresswoman Ellen Tauscher now confirmed in the key position of Under Secretary of State for Arms Control and International Security, conditions for changing the space export control law are the most favorable they have been for the last decade.

[15] "Briefing of the Working Group on the Health of the US Space Industrial Base and the Impact of Export Controls," (Washington: Center for Strategic and International Studies, February 2008).

[16] Ambassador Donald A. Mahley, "Remarks on the State of Space Security," The State of Space Security Workshop, Space Policy Institute, George Washington University, Washington, 1 February 2008.

[17] Reaching Critical Will, "Preventing the Placement of Weapons in Outer Space: A Backgrounder on the draft treaty by Russia and China. For an outstanding analysis of trigger events for space weaponization and why space-basing is not necessarily the most important consideration, see Barry D. Watts, *The Military Use of Space: A Diagnostic Assessment* (Washington, DC: Center for Strategic and Budgetary Assessments, February 2001), 97-106. Watts argues that: "There are at least two paths by which orbital space might become a battleground for human conflict. One consists of dramatic, hard-to-miss trigger events such as the use of nuclear weapons to attack orbital assets. The other class involves more gradual changes such as a series of small, seemingly innocuous steps over a period of years that would, only in hindsight, be recognized as having crossed the boundary from force enhancement to force application. For reasons stemming from the railroad analogy … the slippery slope of halting, incremental steps toward force application may be the most likely path of the two." Watts discusses high-altitude nuclear detonations, failure of nuclear deterrence, and threats to use nuclear ballistic missiles during a crisis as the most likely of the dramatic trigger events.

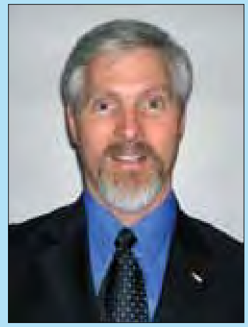
[18] Philip J. Baines, "The Prospects for 'Non-Offensive' Defenses in Space," in James Clay Moltz, ed., *New Challenges in Missile Proliferation, Missile Defense, and Space Security* (Monterey: Center for Nonproliferation Studies Occasional Paper no. 12, Monterey Institute of International Studies, July 2003), 31-48.

[19] Pollpeter, *China's Progress in Space Technology*, 48-50.

[20] Michael Pillsbury, "An Assessment of China's Anti-Satellite and Space Warfare Programs, Policies, and Doctrines," report prepared for the US-China Economic and Security Review Commission, 19 January 2007, 48.

[21] Bruce W. MacDonald, *China, Space Weapons, and US Security* (New York: Council on Foreign Relations, September 2008), 34-38.

[22] Kathrin Hille, "China General Sees Military Space Race," *Financial Times*, 3 November 2009.



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The Imperative of Space Cooperation in an Environment of Distrust: Working With China

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International cooperation in the exploration and use of space would, at first look, seem to be an obvious and relatively achievable American goal. The truth is somewhat more complicated. In 2009, the National Research Council (NRC) of the National Academies released a report titled "America's Future in Space: Aligning the Civil Program with National Needs" in which the NRC recommends, first and foremost, that space program capabilities be better aligned with our most important national goals, including some that are not traditionally connected to space exploration. The NRC also specifically emphasizes greater international cooperation in space, with the White House taking the lead, "as a means to advance US strategic leadership and meet national and mutual international goals."[1] In 2009 as well, the Review of Human Spaceflight Plans Committee, (also known as the Augustine Commission, for its chairman, Norm Augustine), released its findings. It too advocates international partnership as a matter both of national economic necessity and international leadership. "Exploration" Augustine's committee wrote, "provides an opportunity to: demonstrate space leadership while deeply engaging international partners; to inspire the next generation of scientists and engineers; and to shape human perceptions of our place in the universe … the ultimate goal of human exploration is to chart a path for human expansion into the solar system. This is an ambitious goal, but one worthy of US leadership in concert with a broad range of international partners."[2]

There are many complications when thinking about international cooperation in space, and some of them are technical or less obvious. But one of them is quite literally huge, the proverbial elephant in the middle of the room unmentioned in these and often other reports: the People's Republic of China.

But if international cooperation in space is so clearly beneficial to the US, why do these blue-ribbon, high level panels even have to reiterate what should be such an inescapable conclusion? There are many complications when thinking about international cooperation in space, and some of them are technical or less obvious. But one of them is quite literally huge, the proverbial elephant in the middle of the room unmentioned in these and often other reports: the People's Republic of China.

Space Cooperation: Opportunities and Obstacles

American reluctance to cooperate with China should not be as significant an impediment to international space efforts as it seems to have become. The US, after all, has a relatively long history of international cooperation on space, even in the midst of serious political complications. The early days of spaceflight, from the 1960s through the late 1970s, were perhaps the Golden Age of cooperation; National Aeronautics and Space Administration (NASA) reached out to work with other organizations, mostly in Europe and Japan, both eager to learn even if they had relatively little to contribute, and who were grateful for whatever opportunities the Americans could offer from their far better funded and supported space program.

This was also a period in which partners in space exploration had to learn to work and live together, with different customs, different legal standards, and often conflicting bureaucratic methods of operation. This produced some interesting learning experiences, such as the Solar-A joint US-Japan project initiated in the 1980s, in which space scientists were able to proceed with their plans only after clever lawyers created what became known as a tamamushi agreement that fulfilled each countries' differing bureaucratic/legal needs. (Tamamushi refers to an iridescent Japanese beetle whose color appears to change according to the angle from which it is viewed.) And some projects were simply the product of sheer political will overcoming ideological differences, such as the legendary Soviet-American Apollo-Soyuz rendezvous in space in 1975.

As international programs matured, other countries advanced on the technology and engineering learning curve, enabling them to contribute more, and cooperative ventures with the US became extended activities rather than one time flights or encounters. Still, the evidently subordinate roles for US "partners," who had little or no input into decision-making, sometimes resulted in strained relationships and caused other nations to often question whether they were really partners or merely sub-contractors. The International Space Station (ISS) is a prime example of both the positive and negative aspects of recent cooperative activities. Initially a partnership between the US, Japan, Canada, and Europe, some of these partners of-

ten felt excluded as NASA carried out multiple redesigns without their input. The goal of the space station was announced by President Ronald Reagan, but after the fall of the Soviet Union, the US unilaterally brought Russia on board as a partner in 1994 without consulting the other members. Then, the whole partnership enterprise was threatened by unexpected demands from the US Department of Defense that it retained the right to use the space station—although for what military purpose was never really clarified—a condition that would have required, due to their own laws, that the Europeans and Japanese withdraw from the project.

Still, the space station has prevailed; it has been continually crewed since 2000, and its greatest success has probably been to demonstrate that countries can work together in space over long periods of time. This political learning has, in some ways, been as important as the science carried out of the station. If the US chooses to de-orbit the station in 2016 as planned, not only will that valuable learning cease, but much of the goodwill built up since 2000 will likely be lost as well.

The China Problem

So why, with this record of relative US success in space cooperation, is China such a thorny problem for American space policy? One severe complication is determining Chinese intentions on Earth, as well as in space. China, like the Soviet Union before it, is something of a strange animal in the international system: it is in theory a revolutionary state that rejects the international status quo, while at the same time it is in practice a major participant in, and even a foundational part of, that same international system of progress and cooperation. China, much to its dismay in years past, is not a part of the ISS, and it has not been fully welcomed (specifically, by the US) into what is sometimes referred to as "the international family of spacefaring nations." Full membership in that "family" would be the brass ring for the Chinese government: it would bring Beijing's space program (and the Chinese communist government generally) a much-desired international legitimacy, as well as recognition of successful Chinese efforts in space.

Initially, in the immediate afterglow of the end of the Cold War, there was limited US-Chinese space cooperation. President George H. W. Bush, for example, allowed US satellites to be launched from Chinese launchers. But American policy changed after the release of the 1999 Cox Commission Report (chaired by Congressman Chris Cox, R-CA) alleging that the Chinese had engaged in the theft of nuclear and missile technologies that represented a serious danger to US national security.[3] A near hysterical response followed from the media, Congress, and the State Department, much of which quickly and quietly dissipated, but draconian and counterproductive export control regulations were instituted that outlived the immediate scandal and are still in place. The Chinese themselves bear some of the responsibility for America's reticence to cooperate with the People's Republic of China in space. With 95 percent or more of spaceflight technology dual-use, or of value to both the civil and military communities, US concerns about Chinese intentions for the use of their wide-spectrum of space capabilities are understandable. While China has claimed it is interested in space for peaceful purposes, there was nothing peaceful about China's 2007 test of a kinetic anti-satellite capability that successfully destroyed another of their satellites in orbit and littered the space commons with all kinds of dangerous junk and debris. Whether it can be argued (and will be, endlessly) whether the Chinese antisatellite weapon (ASAT) was developed for defensive or offensive purposes, the fact remains that it was created and tested and now exists. And whatever China's intentions, the test was a show of force that not only proved an ability to fight in space, but also irresponsibly created so much debris that it virtually doubled the amount of hazards in orbit, which in itself raised reasonable doubts as to China's actually commitment to being a responsible member of the spacefaring community.

More recently, in November 2009, just prior to President Barack Obama's trip to China, a senior Chinese Air Force officer, Xu Qiliang, made public statements about the military use of space which were immediately interpreted as a major Chinese policy shift in favor of the weaponization of space.[4] Since then, Xu's comments have been the source of considerable speculation. Was there a translation error? Some commentators and interpreters claim he said "weapons in space were an inevitability," while others interpreted his comments to mean that the extension of war into space was an inevitability—an important distinction in a military culture steeped in Leninist understandings of the politics of war. Subsequently, a Chinese Foreign Ministry spokesman quickly reiterated that China opposes the weaponization of space or space arms races of any kind, but that in itself raised the consequent question of who really runs China's space program, the military or the civilians.[5] Deciphering intent is difficult when the technology is dual use, and when a non-Western language and culture are already the source of conflicting Western interpretations.[6] Clearly, however, General Xu's statement was at best ill-timed and even inept, and only adds to a litany of American concerns about the Chinese space program, some with more substantiation than others, including: the unambiguous 2007 ASAT test; claims of Chinese laser blinding of US satellites; claims of the deliberate and dangerous release of a microsatellite with potential ASAT capabilities

China, like the Soviet Union before it, is something of a strange animal in the international system: it is in theory a revolutionary state that rejects the international status quo, while at the same time it is in practice a major participant in, and even a foundational part of, that same international system of progress and cooperation.

near the ISS in 2008; and the clear overall increase of the entire spectrum of Chinese space capabilities. Some of these Western worries are the natural result of technological progress, while others are self-inflicted Chinese political wounds that are the result of a tone-deafness to international politics not seen since the heyday of the Soviet Union's many strategic blunders in the late 1970s. Whatever their source, they have created an environment of distrust and even trepidation in some US policy circles regarding working with the Chinese in space.

A New Mandate

On 17 November 2009, the White House, in conjunction with President Obama's first visit to China, at the invitation of Chinese President Hu Jintao, released a US-China Joint Statement.[7] As might be expected, it calls for increased dialogue and exchanges, but it also specifically notes that the "US and China look forward to expanding discussions on space science cooperation and starting a dialogue on human space flight and space exploration based on the principles of transparency, reciprocity, and mutual benefit. Both sides welcome reciprocal visits of the NASA administrator and the appropriate Chinese counterpart in 2010." On the same day, NASA administrator, retired Marine Corps Major General and former astronaut Charles Bolden, Jr., stated that he is ready to cooperate with China on space exploration and "make them a partner."[8]

China is acutely aware, as are all the current ISS partners, that the US is not always the most reliable partner on space projects; what is a national priority in Washington today might be forgotten and a never-passed piece of legislation tomorrow.

Additionally, Air Force General Kevin P. Chilton, head of US Strategic Command, had stated earlier in the month that he wanted to better understand where China was heading in space, as well as their intentions.[9] Subsequent to "frank dialogue" with China's vice-chairman of the Central Military Commission in October, Chilton had also spoken "passionately," as one reporter described it, about the potential for West Coast missile defense to be destabilizing in relations with China. "What does it make the Chinese think?" Chilton asked.[10] Clearly, both the US and China have questions that only dialogue and exchanges, rather than speculating from a distance, can improve.

The Americans are not blameless in the poor condition of US-Chinese space cooperation; there have been significant moments of suspicion, bordering on outright paranoia, over aspects of the Chinese space effort that in any other nation would be considered a normal part of the spacefaring agenda. Because of dual-use technology, virtually everything the Chinese launch into orbit, from weather satellites to humans, is considered a military asset and a threat to the US. But unlike the Russians and the Americans, who over time learned the "rules of the road" with each other everywhere from the high seas to the high frontier—and even in handling a massive competition in strategic nuclear weapons—there are still senior Chinese and American policymakers, particularly in the military, who seem singularly incapable of grasping how each other's actions look beyond their own borders. The answer now, as it was with the Soviets during the Cold War, is more engagement, not less.

A Way Forward

One promising step forward in the November US-China joint statement is that it specifically focuses on expanding already existing (although currently limited) cooperation between the US and China on space science, with exploration to follow. This is the most likely avenue for restoring and expanding cooperation with China in space. Historically, space science has always been an area ripe for early cooperative ventures for three reasons. First, space scientists are driven by goals determined by nature rather than politics and so are eager to work with their colleagues—in any country—in such substantive but somewhat esoteric and often under-funded areas such as the magnetosphere, the solar corona, solar-terrestrial physics, or planetary sciences. The key for the US and China will be to find areas where each side can make valuable contributions to joint projects. Second, because of the nature of the substantive fields, the technology transfer risks and potential spin-off benefits to military space programs that have inhibited space cooperation with China to date are minimized. Third, cooperating with China on space science provides a venue to learn more about how China works; no matter how well the scientists might understand each other in front of the same blackboard, the fact remains that differing cultural, political, and bureaucratic aspects of cooperation with any potential partner can frustrate or even tank any joint project, especially as dialogue is expanded to include exploration and even human spaceflight. Space science projects provide a kind of essential honeymoon period where two nations, just like two individuals, can get used to living with each other. The need for such a learning period should not be underestimated—and neither should it be accelerated too quickly. The level of distrust on both sides makes it imperative that expectations be initially kept low.

There will be scientists and engineers working as part of the Chinese human spaceflight program and its robotic Chang'e lunar program, who are going to be less than enthusiastic about potentially working with the US. Much like those at NASA who often feel both underappreciated and underfunded, the Chinese space community feels their political support and funding to carry out their stated goals is tenuous. They have worked hard to establish and meet their official goals, which to date do not include a manned lunar landing, but is something they hope for in the future. There is, for these Chinese scientists, a risk to working with the US, whose haphazardly funded and supported technological successes make the American program the erratic hare to China's slow, plodding, but consistent tortoise. American inconsistency or a shift in the short attention span that is the curse of a long-term space program in a volatile de-

mocracy could jeopardize Chinese long-term plans. China is acutely aware, as are all the current ISS partners, that the US is not always the most reliable partner on space projects; what is a national priority in Washington today might be forgotten and a never-passed piece of legislation tomorrow. The US must move forward not only with China but with all US partners at a rate it is prepared—and committed—to sustain.

The key to the future in space, and all areas of US-China relations, is dialogue. The US must better understand how China works; its goals, and intentions, as well as making a clear effort to become better understood, in terms of not just policies and processes, but intentions. The Chinese, for their part, have now been players in the international system long enough to know that Cold War-type snarling about wars in space or juvenile displays of power in Earth's orbit can no longer be passed off or excused as the missteps of an immature or ideologically blinkered power. Words and actions, on both sides, have consequences. Because of the dual-use nature of space technology, dialogue between NASA officials and its counterparts will not be enough. The military, including and perhaps especially Air Force Space Command, must actively pursue opportunities to get to know their Chinese counterparts and how they work, especially as the Chinese, for a variety of political and ideological reasons, are unlikely to be the first to take such steps themselves. Chinese concerns consequent to US rhetoric about dominating space and an inability to decipher who actually controls the space policy generally, NASA or the military, or specific systems such as the missile defense system that General Chilton referenced—Strategic Command or Pacific Command—are obstacles to be overcome as well. Ambiguity in communications and speculation about intentions serves no one well; one of America's greatest strengths is our open and transparent system of government and diplomacy, and we lead by example in opening greater cooperation with China in space. The benefits could be far greater, even here on Earth, than we might expect.

Notes:

[1] "America's Future in Space: Aligning the Civil Space program with National Needs," Committee on the Rationale and Goals of the US Civil Space Program," National Research Council, National Academies Press, 2009, 7.

[2] "Summary Report of the Review of US Human Space Flight Plans Committee," NASA web site, http://www.nasa.gov/pdf/384767main_SUMMARY%20REPORT%20-%20FINAL.pdf, 2.

[3] US National Security and Military/Commercial Concerns with the People's Republic of China, US House of Representatives, http://www.house.gov/coxreport/.

[4] Stephen Chen and Greg Torode, "China 'to put weapons in space,'" *South China Morning Post*, 3 November 2009.

[5] *Agence France Presse*, "China disavows general's comments on space militarization," 5 November 2009. It is interesting to note that this report seems to confuse the militarization of space, a reality since the 1940's, with the weaponization of space, a Rubicon approached, but one most individuals assert as not yet fully crossed.

[6] Joan Johnson-Freese, "Strategic Communication with China: What Message About Space?" *China Security*, Issue 2, 2006; Joan Johnson-Freese, "Strategic Communications With China About Space," *Space and Defense* 2, no. 3 (Spring 2009): 53.

[7] The White House, US-China Joint Statement, 17 November 2009. www.whitehouse.gov/the-press-office/us-china-joint-statement.

[8] *Agence France Presse*, "NASA ready to work with China on space exploration," 17 November 2009.

[9] Lolita C. Baldor, *Associated Press*, "US Eyes China's rapid advancements in space," 3 November 2009.

[10] Colin Clark, "Stratcom Signals PRC on Missile Defense," 10 November 2009, http://www.dodbuzz.com/2009/11/10/stratcom-signals-prc-on-missile-defense/.

Dr. Joan Johnson-Freese has been chair of the National Security Decision Making Department at the Naval War College in Newport, Rhode Island since 2002. Previously, she was on the faculty at the Asia Pacific Center for Security Studies in Honolulu, Hawaii; the Air War College in Montgomery, Alabama; and director of the Center for Space Policy &and-Law at the University of Central Florida.

Within international and national security studies, Dr. Johnson-Freese focuses on globalization and technology programs and policies generally, and space programs and policies specifically, including issues relating to technology transfer, missile defense, and space security. Dr. Johnson-Freese has testified before Congress on several occasions regarding Chinese space activities and space security issues. She is on the editorial board of China Security, a member of the International Academy of Astronautics, the International Institute for Strategic Studies, the International Space University, served on the Space Studies Board of the National Academy of Sciences, and the Lyles Commission to examine the future of the US civil space program, and an adjunct professor at the Watson Institute, Brown University.

Recent books include *Heavenly Ambitions: America's Quest to Dominate Space*, (University of Pennsylvania Press, 2009), and *Space as a Strategic Asset*, (Columbia University Press, 2007). Prior books include: *The Chinese Space Program: A Mystery Within a Maze* (Krieger Publishing, 1998); *Space: The Dormant Frontier, Changing the Space Paradigm for the 21st Century*, (Praeger Publishers, 1997); *The Prestige Trap: A Comparative Study of the US, European and Japanese Space Programs*, with Roger Handberg, (Kendall-Hunt, 1994); *Over the Pacific: Japanese Space Policy Into the 21st Century*, (Kendall-Hunt, 1993); and *Changing Patterns of International Cooperation in Space*, (Krieger Publishing, 1990). She has also published over 80 journal articles relating to international space cooperation and competition issues.

How International Collaboration is Improving Space Situational Awareness

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By now, we all have seen the statistics: since the beginning of 2007, the number of objects in the public satellite catalog has grown from 10,136 objects in Earth orbit to 15,288 today—a 50 percent increase in less than three years. Over 80 percent of these new objects are the result of just two events: the January 2007 Chinese test of an anti-satellite weapon against FengYun 1C (2,691 objects) and the February 2009 collision of Iridium 33 and Cosmos 2251 (1,632 objects). As of today, less than three percent of these debris objects have decayed from orbit and many will remain in orbit for decades or centuries to come, creating a continuing hazard for space operations.

In fact, the debris from these two events have already considerably complicated operations for satellite operators in low Earth orbit (LEO)—operating constellations such as the Iridium, Orbcomm, and Globalstar communications networks and many Earth resources satellites. For Iridium and Orbcomm alone, these debris now account for 50 to 60 percent of all predicted close approaches, or *conjunctions*, within five kilometers of their satellites—or more than double the number from before 2007. Obviously, the space operations community needs to work together now to reduce the likelihood of similar events happening again.

The good news is that the international community has already been working together since early 2008 to share orbital data with the goal of mitigating the risk of additional on-orbit collisions. In order to understand the benefits of this collaboration and see how to improve its effectiveness, we will need to first understand the limitations of today's space surveillance systems that help avoid conjunctions and how data sharing can overcome some of those limitations.

Limitations

The statistics provided above were derived from the public data released from the US Space Surveillance Network (SSN) catalog. That network is a collection of dedicated, collateral, and contributing radar and optical sensors designed and built in the 1960s, 1970s, and 1980s for an entirely different purpose than collision avoidance—to track Soviet satellites and detect incoming ballistic missiles. To perform these missions, the radars of the SSN were designed to be capable of tracking objects 10 centimeters or larger in LEO (out to 5,000 kilometers) while the optical sensors (telescopes) are capable of tracking objects one meter or larger in geostationary orbit (GEO) (around 36,000 kilometers).

With these capabilities, the SSN currently tracks over 20,000 objects. Only 15,000 of these objects are in the public catalog, however, and available to satellite operators for screening close approaches with their satellites. The remaining 5,000 objects are kept in a separate catalog because they need additional work to refine their orbits and define their origin.[1] And National Aeronautics and Space Administration (NASA) currently estimates more than 500,000 objects in Earth orbit one to 10 centimeters in diameter—each more than capable of disabling a satellite in a hypervelocity impact—few of which can be tracked by the SSN.[2]

To further complicate the problem, the SSN was specifically designed to use noncooperative tracking—that is, tracking each space object without any type of active cooperation from the object itself. In order to provide tracking on as many objects as possible, the SSN obviously cannot rely on cooperative tracking from debris or satellites whose operators may not wish to cooperate. Noncooperative tracking works reasonably well for debris objects, but presents significant limitations when tracking operational spacecraft, since this method must detect and process maneuvers after the fact—resulting in delays in providing updated orbits. And detecting maneuvers on GEO satellites can be even more challenging since current ground-based optical systems are not capable of day-night, all-weather operations—potentially delaying the acquisition of observations immediately following a maneuver. Under such conditions, satellite orbit estimates can degrade, resulting in the SSN being unable to associate new observations with the correct satellite (cross-tagging) or even 'losing' the satellite. As a result, even the objects that can be tracked by the SSN may not be tracked accurately enough to provide satellite operators confidence in their conjunction predictions.

Given the current state of affairs, it would seem that there is little that satellite operators can do to protect their satellites. Yet, we will see that a more thorough review of existing complementary capabilities suggests that parts of the problem can

The good news is that the international community has already been working together since early 2008 to share orbital data with the goal of mitigating the risk of additional on-orbit collisions.

be addressed through collaboration, freeing up more capable resources to focus on the particularly challenging aspects of providing improved space situational awareness (SSA).

Today's Solutions

As with any complex problem, the solution to this problem will not be simple. There are many facets to improving SSA which provide opportunities to quickly leverage existing capabilities to move toward immediately mitigating the risk of on-orbit collisions. A judicious approach of starting with the most immediate opportunities, while identifying potential ways to address other shortcomings, should achieve the most expedient results.

We can begin by turning one of the primary limitations of the current SSN into an advantage by realizing that while each maneuvering satellite can be difficult to track using noncooperative tracking, that each of these satellites is operational—which means that there is an operator responsible for maintaining its orbit. Satellite operators must maintain accurate orbits for their satellites in order to be able to plan state-of-health contacts and support anomaly resolution, thermal and power management, attitude maintenance, and periodic orbit adjustments. In most cases, today's satellite operators use active ranging or onboard global positioning system to provide orbits which have been shown to be an order of magnitude better than noncooperative tracking can produce and which ensure the proper identification (correlation) of the observations. And, of course, the satellite operator knows when maneuvers are planned to be conducted and what the post-maneuver nominal orbit should be.

Operator	Headquarters Location
Intelsat	Bermuda
Inmarsat	United Kingdom
SES	Luxembourg
EchoStar	US
National Oceanic and Atmospheric Administration	US
Star One	Brazil
Telesat	Canada
European Organisation for the Exploitation of Meteorological Satellites	Europe (Germany)
Israel Aerospace Industries	Israel
Paradigm	United Kingdom
Optus	Australia
Indovision	Indonesia
Iridium	US
Orbcomm	US
GeoEye	US
DigitalGlobe	US
Canadian Space Agency	Canada
Geo-Informatics and Space Technology Development Agency	Thailand

Table 1. Current International Data Center Participants.

In fact, this realization was the basis for establishing the current international data center, operated by the Center for Space Standards and Innovation (CSSI) on behalf of its members. The data center supports 18 satellite operators from at least 11 countries, as seen in table 1. CSSI screens over 260 of their satellites—in both LEO and GEO—which represents one-quarter of all operational satellites in Earth orbit. These conjunction screenings are automatically performed twice each day, using the best orbital data available, and take just over 20 minutes on a standard desktop computer. Each operator provides their own orbital data—including planned maneuvers—to CSSI for these conjunction assessments. CSSI ensures that all data is correctly transformed to standard orbital data formats for subsequent use. When combined with SSN data for non-member satellites and debris, it provides the best overall SSA for screening close approaches available today.

Operators are able to specify threshold conditions and values to be used in providing automated warnings (e.g., any object coming within five kilometers of any of their satellites). Operators have full access to the conjunction analysis in a secure online system, which includes the orbital data used for the conjunction assessments, so that they can quickly and reliably perform additional analysis to determine whether they wish to perform a collision avoidance maneuver and what the most efficient maneuver would be, based upon their mission requirements.

The Way Ahead

Not only does this approach provide improved SSA for satellite operators and support more efficient decision making, it could be used by the Joint Space Operations Center (JSpOC) at Vandenberg AFB, California to improve their SSA, too. Instead of having to dedicate additional resources to closely tracking and recovering maneuvering satellites, the JSpOC could simply use the SSN to verify reported orbits periodically, freeing up SSN resources for tracking noncooperative objects. If problems were detected during verification of certain satellite orbits, the JSpOC would simply fall back to the standard noncooperative tracking approach.

Of course, to encourage maximum participation by satellite operators in such a data sharing arrangement, the US must be willing to reciprocate by sharing the best available orbital data they have on as many objects as possible. That means US data policy should be changed to support the release of high-accuracy orbital data. Given that over 95 percent of the 20,000 objects currently tracked by the SSN are dead satellites or debris and less than one percent are operational US Department of Defense or intelligence satellites, why would the US not want to share this data if it meant helping to avoid a repeat of the Iridium 33 collision with Cosmos 2251—a dead Russian communications satellite. Sharing this data with the satellite operators would also allow the operators to perform their own

conjunction screenings, reducing the need for the JSpOC to take on that task for them.

Having more accurate orbital data would significantly reduce the number of false alarms, which currently undermine operator confidence in conjunction assessments. An order of magnitude improvement in accuracy reduces the threat volume by a factor of 1,000 and makes the collision avoidance problem far more manageable.

Even if there were a problem with releasing the entire high-accuracy catalog to the public, allowing it to be used by the international data center for screening close approaches—and only releasing orbital data to satellite operators for individual conjunction events involving their satellites—would go a long way toward reducing the risk of another collision in orbit.

Need for Additional Collaboration

The establishment of the international data center in such a short period of time is a great step forward in developing a global network of satellite operators working together to reduce the risk of on-orbit collisions. But much work remains to be done to bring in other satellite operators into the system. After all, the more operators that participate in such a system, the more benefit will be seen by all.

Bringing in high-accuracy data from the SSN would also be a big step forward, particularly for LEO operations, in providing better SSA for the large amounts of orbital debris there. But the space surveillance networks of other major space players—most notably Europe, Russia, and China—would further enhance SSA. And there is potential to bring in research networks—such as the International Scientific Observing Network—which are using very capable systems to study the orbital debris population. In order to perform their research to detect hard-to-track objects, they must also maintain catalogs of other objects—all data which could be used by satellite operators to avoid conjunctions.

Of course, NASA and European Space Agency studies showing very large numbers of objects smaller than can be currently tracked by current space surveillance systems point out the need for even more capable sensors and more effective correlation techniques to match observations with objects. Here again, international collaboration could help ensure funding and a robust global view of the near-Earth space environment.

Finally, there is a continuing need to establish standards for safer space operations. Current international standards which allow dead spacecraft to remain in Earth orbit for up to 25 years are simply too lax. Iridium 33 was destroyed by Cosmos 2251, which is believed to have ceased operations two years after being launched in 1993, and then drifted for another 14 years before the collision. Obviously, we need to be much better stewards of the space environment.

Moving Out

Clearly, there are plenty of challenges to providing improved SSA and safer space operations. The good news is that the international community is already working hard to move forward on improving things today. The international data center and its members welcome participation from all satellite operators worldwide, together with national and research space surveillance networks, to help continue to improve things tomorrow.

Notes:

[1] Satellite Situation Report, Space Track, data, 14 December 2009, www.space-track.org.

[2] NASA, FAQs, NASA Orbital Debris Program Office, data, http://www.orbitaldebris.jsc.nasa.gov/faqs.html.

Dr. T. S. Kelso (BS, Physics and Mathematics, US Air Force Academy [USAFA]; MBA, Quantitative Methods, University of Missouri-Columbia; MS, Space Operations, Air Force Institute of Technology [AFIT]; PhD, Operations Research, The University of Texas at Austin) is a senior research astrodynamicist at the Center for Space Standards and Innovation in Colorado Springs, Colorado. He has supported the space surveillance community since 1985 by operating electronic data dissemination systems (CelesTrak) to provide two-line orbital element sets, associated orbital models, documentation, software, and educational materials to users around the world. He currently operates the international data center supporting conjunction analysis for 19 satellite operators and over 250 Earth-orbiting satellites.

Dr. Kelso was commissioned through the USAFA in June 1976. He served as an intercontinental ballistic missile combat crew member at Whiteman AFB, Missouri before being assigned as an instructor at the 4315th Combat Crew Training Squadron at Vandenberg AFB, California. Later, at Sunnyvale AFS, California, he developed the training plans for the activation of Schriever AFB, Colorado and then headed up the Global Positioning System Operations Team for the last two Block I launches.

Dr. Kelso served on the faculty at AFIT as the director of the Graduate Space Operations Program before being selected to work the chief of staff's SPACECAST 2020 and Air Force 2025 future studies. While at Maxwell AFB, Alabama, he also served on the faculty of Air Command and Staff College, Air War College, and the College of Aerospace Doctrine, Research, and Education.

Dr. Kelso returned to AFIT to serve as the associate dean in the Graduate School of Engineering, vice commandant, and commandant. From there, he was selected to be the first director of the Air Force Space Command Space Analysis Center, where he led all Department of Defense analysis in support of the Columbia Accident Investigation and was a member of National Aeronautics and Space Administration's Near-Earth Object Science Definition Team study. He retired as a colonel in 2004 after almost 28 years of commissioned service.

Dr. Kelso has been awarded the Legion of Merit with oak leaf cluster, Meritorious Service Medal with oak leaf cluster, Air Force Commendation Medal with oak leaf cluster, and Air Force Achievement Medal. He is a Fellow of the American Astronautical Society and an Associate Fellow of the American Institute of Aeronautics and Astronautics.

NASA, Exploring the Boundaries of International Cooperation

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Since its inception in 1958, the National Aeronautics and Space Administration (NASA) has enjoyed significant benefits in almost all of its major programs through various levels of international cooperation. In the past 50 years, NASA's international cooperative activities have involved more than 3,000 agreements with over 100 nations or international organizations. While the majority of NASA's cooperation is accomplished with space-faring nations, an increasing number of other nations are now relying on space for day-to-day activities, such as urban planning, resource management, disaster preparedness and response, communications, weather forecasting, and navigation. As a result, NASA's international partnerships have continued to grow in diversity and importance, as the agency engages developed and developing nations in a wide range of mutually beneficial activities.

In keeping with the National Aeronautics and Space Act of 1958 and relevant national space policies, NASA has developed a series of guidelines to govern its international activities. First, cooperative activities must have scientific and technical merit and demonstrate a specific programmatic benefit to NASA. These benefits are often achieved by pooling resources, accessing foreign capabilities or geographic advantage, adding a unique capability to a mission, increasing mission flight opportunities, or enhancing scientific return. Next, in almost all instances, each partner funds its respective contribution such that the cooperation is conducted on a "no exchange of funds" basis. The cooperation is structured to protect against unwarranted technology transfer, taking into account US industrial competitiveness, and establishing clearly defined managerial and technical interfaces to minimize complexity. Finally, NASA's approach is predicated on respect for the national prerogatives of prospective participating nations. Since space exploration is, by its very nature, a multi-year, multi-faceted undertaking, NASA desires flexible opportunities for international cooperation that can be tailored to each nation's interests.

Currently, there is significant international cooperation in each of NASA's four Mission Directorates (science, space operations, exploration systems, and aeronautics research) involving hundreds of active agreements. This cooperation includes a broad range of activities such as: joint mission planning and development of human space flight systems on the International Space Station; flight of international astronauts on NASA's space shuttle; flight of NASA instruments on international spacecraft (and vice-versa); close coordination of independent space activities with similar mission objectives; suborbital campaigns and field research (e.g., measurements from sounding rockets, balloons, aircraft, and ground-based measurements); tracking and space communications interoperability; and scientist-to-scientist data exchanges with joint analysis and publication of results. NASA is also engaged in discussions with new and existing international partners to support human and robotic space exploration beyond low Earth orbit.

International Cooperation Related to Science

As might be expected, international cooperation in a wide range of science and technology initiatives is most evident in NASA's Science Mission Directorate, whose activities fall broadly under the categories of Earth science and space science. The agency has established a robust program of scientific research, guided by input from the global science community, from National Academy of Sciences' studies and decadal surveys, and from NASA external advisory committees. International involvement has historically been welcomed at all levels, ranging from multi-million dollar contributions of instruments

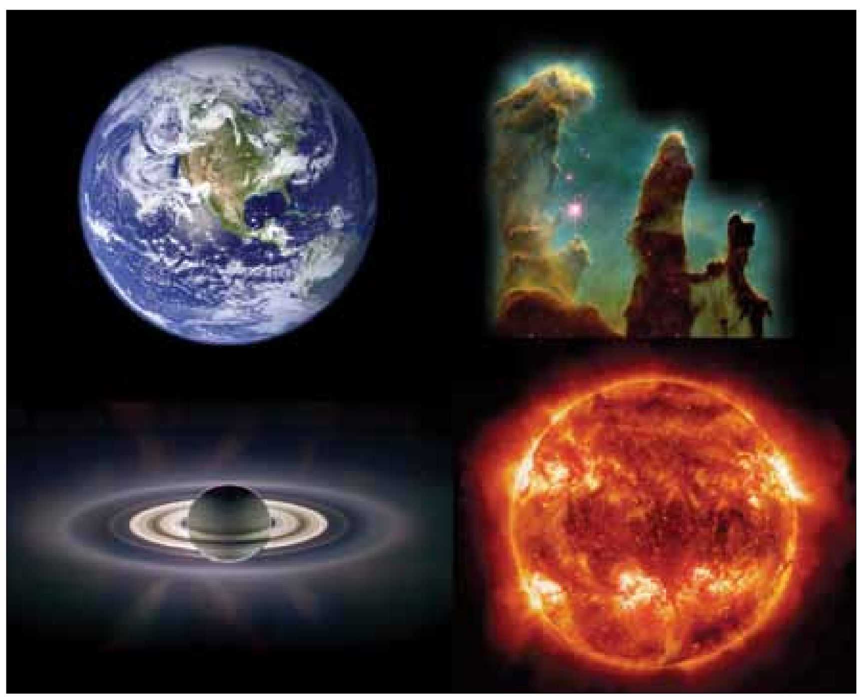

Figure 1. Over half of the 48 NASA science activities in Earth observation, astrophysics, planetary exploration, and heliophysics have significant international participation.

and spacecraft to modest data analysis by individual researchers from around the world. At the present time, two-thirds of NASA's 455 active international agreements are for missions led by the Science Mission Directorate. It should also be noted that more than half of NASA's 48 currently-operating science missions include international participation. It is anticipated that this involvement will continue to grow as NASA and international institutions with similar research objectives seek to maximize scientific return with limited domestic resources for mission development and operations. On a daily basis, the benefits for the broader scientific community are realized as NASA and its international partners make their research data available on a global basis.

NASA's Earth science activities are inherently global as we strive to understand the Earth from a variety of US and international platforms. In fact, some ground-based research programs involve dozens of countries such as the Aerosol Robotic Network (AERONET), an optical, ground-based aerosol-monitoring network and data archive system in which over 40 countries participate. In addition, NASA is a recognized leader in international organizations such as the Committee on Earth Observation Satellites (CEOS), which coordinates the civil space missions of nearly 50 international space agencies and organizations involved in the observation and study of the Earth. Earth observation from a variety of international space-based platforms, input from ground-based networks such as AERONET, and global coordination by organizations such as CEOS are all necessary to achieve the ultimate goal of a full understanding of the Earth as a system of interactions among dozens of complex processes.

Some space science missions with international involvement are well known, such as the Hubble Space Telescope, which includes cooperation between NASA and the European Space Agency (ESA), and its follow-on mission, the James Webb Space Telescope, in which NASA, ESA, and the Canadian Space Agency are partners. For robotic planetary missions, cooperation with multiple international partners is generally the norm. For example, 17 nations contributed to building Cassini-Huygens, a cooperative mission led by NASA, ESA, and the Italian Space Agency to explore Saturn, Titan, and the other moons of Saturn. Hundreds of scientists worldwide participate in the Cassini-Huygens science teams.

Other small, low-cost, less-known activities in partnership with other US government agencies and international organizations can have significant US foreign policy benefits as well. For example, working closely with the US Agency for International Development (USAID) and international organizations, NASA has initiated a number of very successful pilot projects, particularly in the area of remote sensing applications. This type of cooperation is exemplified by NASA's involvement in the establishment of the SERVIR initiative that integrates satellite observations, ground-based data, and forecast models to monitor and forecast environmental changes and to improve response to natural disasters. SERVIR enables scientists, educators, project managers, and decision makers to respond to a range of issues including disaster management, agricultural development, biodiversity conservation, and climate change. Endorsed by governments of Central America and East Africa and principally supported by NASA and USAID, SERVIR has a strong emphasis on the availability of searchable and viewable Earth observations, measurements, animations, and analysis. A SERVIR coordination office and a rapid prototyping facility are located at NASA's Marshall Space Flight Center in Huntsville, Alabama. Regional SERVIR nodes are located at the Water Center for Humid Tropics of Latin America and the Caribbean in Panama and the Regional Center for Mapping of Resources for Development based in Kenya.

International Cooperation Related to Space Operations

NASA's premier example of international space cooperation is the ongoing assembly and operation of the International Space Station, the world's largest international construction effort in space. With participation from 15 nations, NASA and four international space agency counterparts have worked together to design, develop, assemble, and operate one of the most complex science and engineering projects in history. Using the space shuttle, NASA has successfully delivered to orbit and assembled a number of key international elements including recently: the European *Columbus* laboratory, the Japanese *Kibo* laboratory, and the Canadian *Dextre* robotic manipulator system. As International Space Station assembly nears completion, a six person international crew operates the station as steady state utilization of this world class research facility begins.

The success of the International Space Station is all the more

Figure 2. The International Space Station, the world's largest international construction effort in space with participation from 15 nations and four international space agency counterparts.

remarkable due to the necessary harmonization of complex engineering and technology development activities among the US, Russia, Japan, Canada, and many nations of Europe. The space station partners represent over a dozen different political systems, budgetary mechanisms, and cultural, management, and industrial approaches that rely on the multilingual skills of engineers, astronauts, and mission-controllers around the world.

The space station partnership has resulted in a robust program with scientific and technological benefits for all of the partners involved. Along the way, the partnership itself has survived significant challenges, such as initial delays in delivery of major components and the tragic loss of space shuttle *Columbia*. The success of this program has played a positive role in the governmental relationship between the US and its partners.

Figure 3. Sixty-one international astronauts from 15 countries have flown on the space shuttle a total of 87 times.

The history of space shuttle crew assignments also clearly demonstrates the global nature of NASA's human space flight program. Sixty-one international astronauts from 15 countries have flown on the space shuttle a total of 87 times, representing roughly one-fifth of the total Shuttle astronauts flown to date. US and international astronauts, by virtue of their unique human space flight experience and the genuine admiration by international audiences, have long been able to transcend government-to-government issues and help to enable constructive discussion on the peaceful uses of outer space.

NASA also enjoys significant international cooperation in support of space communications in which NASA and the international community routinely provide back-up communication services for one other. NASA leads the development of international data standards and protocols for such space communications activities and participates in the International Telecommunication Union to ensure that sufficient radio frequency spectrum is allocated appropriately to all international partners. NASA also provides communications services between the US and the US South Pole Station and, through these services, is supporting a number of international science projects that were launched under the banner of the United Nations' International Polar Year.

International Cooperation Related to Future Exploration Activities

In 2004, the president and subsequently the US Congress directed NASA to pursue a new direction for space exploration known as the US Space Exploration Policy. As part of this policy, NASA was tasked to pursue opportunities for international cooperation to support US space exploration goals. More recently, human space flight activities related to this policy were reassessed as part of the Review of US Human Space Flight Plans. The final report of this review was completed in October 2009, and highlights, among other conclusions, the importance of international cooperation in future human space exploration activities.

Over the past five years, NASA has made steady progress with its international counterparts in the development of overall objectives for space exploration. Most significantly, NASA and 13 space agencies from around the world developed "The Global Exploration Strategy: The Framework for Coordination," released by the participating agencies in May 2007, expressing a shared vision regarding the importance of space exploration as it relates to national objectives.[1]

For NASA, international cooperation in future space exploration has been implemented using parallel paths, a multilateral approach to information sharing and coordination, while seeking to identify specific new bilateral cooperation with individual interested space agencies. Some examples of bilateral cooperation that have resulted from this process include: NASA's cooperation with the Japanese Aerospace Exploration Agency on its lunar orbiter Kaguya; cooperation with the Indian Space Research Organization on its Chandrayaan lunar mission, in which NASA provided a miniature synthetic aperture radar to map ice deposits in the Moon's polar regions and a Moon mineralogy mapper to assess mineral resources of the Moon; and cooperation with the Russian Federal Space Agency on Russian provision of neutron detectors for NASA's Lunar Reconnaissance Orbiter and NASA's Mars Science Laboratory missions.

International Cooperation Related to Aeronautics Research

NASA has a successful history of international cooperation in its aeronautics research programs, primarily in the areas of fundamental aeronautics research and aviation safety. On the national level, such cooperation is specifically encouraged by the National Aeronautics Research and Development Policy of 2006, which directs the US government, among other activities, to "continue to pursue, as appropriate, international cooperation on aeronautics research and development activities through mutually beneficial cooperation with foreign nations

and/or consortia to further the peaceful use of the sky and for other civil and scientific purposes." In fundamental aeronautics research, NASA is working with other nations on cooperation related to topics such as reductions in carbon dioxide emissions and rotorcraft technology. In aviation safety, NASA is working with international partners in areas such as human factors and icing research.

International Cooperation With Non-Traditional Partners

As noted above, NASA has a long history of international cooperation, including agreements with organizations in over 100 countries. Much of this cooperation is conducted with a handful of nations that have, in essence, become NASA's "traditional" partners. For example, 50 percent of NASA's active agreements are with eight partners, five of which are in Europe, and the remaining 50 percent are spread among about 100 other countries. NASA is considering the means by which it can expand its "global reach," particularly in areas of scientific research, education, and Earth science applications, via engagement with these "non-traditional partners" to find mutually beneficial activities that are easy to implement at a low cost, yet have a high impact for both the potential partner and NASA.

Smaller nations have, in the past, made meaningful contributions to NASA's programs, even when their roles have been modest. In return, cooperation with NASA has provided these partners, in some cases, with access to world-class research facilities, new technology applications, and unprecedented collaboration with world renowned scientists and engineers. Looking to the future, NASA is interested in ways to increase the participation of these non-traditional partners in almost all aspects of its activities. Such participation could have benefits for NASA missions, as well as significant foreign policy benefits for the US government.

Conclusion

NASA's international activities have been a key component of the agency's overall mission since its inception more than fifty years ago. While NASA's international cooperation is pursued for scientific, programmatic, and mission-related purposes, it also provides significant benefits to the US more broadly and, as such, often requires close coordination with other US government agencies. NASA's high visibility civil space cooperation with its international counterparts has proven time and time again to be a good news story in otherwise strained government-to-government relationships.

NASA's mandate to seek international involvement in its activities, combined with effective, long-standing relationships with the White House Office of Science and Technology Policy, the National Security Council, the Department of State, and other organizations in the executive branch, provides a basis for the development and implementation of NASA's international cooperation around the globe in a manner that is beneficial to other US government goals.

International cooperation will continue to be fundamentally important as NASA pursues a bold program of human and robotic exploration, science, and aeronautics research. It is clear that our international partners appreciate the consistent message from the US government in general, and NASA in particular, that we desire international collaboration in all aspects of our activities. Each partner also appears to welcome continued NASA leadership as we implement an exciting new chapter in space exploration. At NASA, we intend to provide that leadership while seeking opportunities for mutually beneficial cooperation around the world, working with our current traditional partners and expanding our activities into regions of the world in which NASA presence has been historically limited.

Notes:

[1] NASA web site, The Global Exploration Strategy: The Framework for Coordination, www.nasa.gov/pdf/178109main_ges_framework.pdf.

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Mr. O'Brien previously served as deputy assistant administrator for external relations (Space Flight). He was responsible for the international aspects of NASA's human space flight activities. He led the team that negotiated the agreements for the International Space Station with space agencies of Europe, Japan, Canada, and Russia. Mr. O'Brien also was responsible for agreements for space shuttle flights for international astronauts and NASA relations with other space agencies, such as those of Israel, China, and India.

Mr. O'Brien came to NASA from the US Navy. He served as a naval aviator in command positions and in Washington on the staffs of the chief of naval operations and the chairman of the Joint Chiefs of Staff. As an advisor to the chairman concerning political-military policy in the Middle East, Africa, and Southwest Asia, he traveled widely in the Persian Gulf area for bilateral discussions with the defense forces of Saudi Arabia, Kuwait, Bahrain, and other nations in the region.

He also served as the deputy director for research at the Institute for National Strategic Studies in Washington. Mr. O'Brien was commanding officer of US Naval Station Roosevelt Roads, Puerto Rico where he designed and executed the $350 million repair and reconstruction program after the station was nearly destroyed by Hurricane Hugo. As a Navy combat pilot, he commanded a Navy carrier-based attack squadron, and has made over 900 aircraft carrier landings in high performance jet aircraft. Mr. O'Brien has also served as a physicist for the Department of the Navy.

As an Olmsted Scholar, Mr. O'Brien performed research in International Relations and Strategic Studies at the Graduate Institute of International Relations in Geneva, Switzerland. He is also a graduate of the French Ecole Militaire in Paris, France.

Opening Up the Aperture

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The significance of satellite communications (SATCOM) in today's joint fight is best described as critical and essential. Space-enabled communications are the force multiplier, integrating and connecting deployed major weapons platforms and weapons systems to the network and coalition partners. Clearly, as illustrated in the asymmetrical challenges faced in Afghanistan and Iraq where increasing numbers of remotely piloted aircrafts (RPAs) orbits are disseminating streaming intelligence, surveillance, and reconnaissance (ISR) data daily, the sum of the parts is greater than the whole. Real-time data collection and dissemination on high value targets to a wider distributed network is occurring time and time again for immediate mission execution. Situational awareness (SA) in mountainous terrain provides high confidence that casualties can be limited while pursuing offensive operations. This capability is powerful and game changing. The demand for SATCOM is inexorable given its unique ability to quickly connect many deployed weapon platforms to the network. The dilemma facing the Department of Defense (DoD) is how to field a SATCOM capability able to satisfy the warfighter's ever evolving need for capacity in a timely and cost-effective way. Smartly evolving current systems and seeking opportunities with commercial satellite providers appears to be the most promising way forward. DoD SATCOM acquisitions need to be agile and responsive to address the anticipated growth in demand. Rapidly deployable hosted payloads on commercial satellites can be leveraged to address shortfalls in theater operations. Future joint SATCOM capabilities need to be matched to the demand, delivered at speed of need, adequately priced, and focused on providing end-to-end integrated and interoperable communications to the warfighter and coalition partners.

From a user perspective, the most important military satellite communications (MILSATCOM) capabilities are: worldwide coverage, connectivity, transfer rate, survivability, protection, mobility, and interoperability. The user would like to connect to the network anytime, anywhere and in all environments. Satisfying this set of requirements requires a portfolio of satellite services; currently this mix includes survivable/protected, wideband, narrowband, and a variety of commercial systems. Future systems will be based upon consideration of current on-orbit systems, systems in development, operational trends, development timelines, and affordability.

Consumer communications trends have made it clear that the demand for capacity is constantly increasing. Technology continues to evolve, as well as applications, enabling new capabilities which in turn drive the need for more capacity and faster access to the information (more bandwidth). The iPhone, HD Pocket Cams, YouTube, MapQuest, and Facebook are examples of these trends.

Our future warfighters are today's young consumers. They are using these devices and services every day. These consumers expect that the applications and hardware platforms be integrated and connected wirelessly (real-time) to entertain, learn, or increase productivity. These consumers expect simple and seamless access to information. The warfighter's expectations are evolving in much the same way.

Our current wars in Afghanistan and Iraq have demonstrated that global ISR weapon systems deliver powerful operational advantages. Global Hawk and Reaper participate every day in multiple operations. The demand for real-time ISR processing, exploitation, and dissemination capability is increasing rapidly. It is anticipated that by next year, Reaper aircraft will have "Gorgon Stare" sensors installed which will be able to film a two-and-a-half mile radius from 12 different angles. Our existing SATCOM architecture and data pipes are insufficient to properly satisfy today's demands and require bandwidth-constrained solutions to support access to large quantities of ISR data. Future ISR and sensor capabilities will be much greater than those in operations today and will require significant SATCOM resources (antenna coverage and bandwidth) to support multiple simultaneous RPA orbits.

Figure 1. An MQ-9 Reaper, armed with laser guided munitions and Hellfire missiles, flies a combat mission over southern Afghanistan.

RPAs are not the only platform with sensors that drive the need for bandwidth. The Army brigade combat team (BCT) modernization strategy requires BCTs to be better equipped in mobile operations that involve precision fires while in threat environments. Integrated ground theater sensors in the future will provide heightened awareness during ground defensive and offensive measures. Sensors will ultimately drive the demand for streaming products that are best served in a net centric environment. Everything will be on and filtered as appropriate to support operational plans and tempo.

Future ISR and sensor capabilities will be much greater than those in operations today and will require significant SATCOM resources (antenna coverage and bandwidth) to support multiple simultaneous RPA orbits.

Each of the satellite communications systems—survivable/protected, wideband, narrowband, and commercial—has unique characteristics that are vital and necessary. Each system will need to be evolved in a practical manner that recognizes that the ground investment needed to communicate with these satellites is of equal importance. Each of the services' communications terminals must be compatible with the satellites servicing them and the platform environment in which they operate. The objective should be to reduce the number of systems requiring differing terminals and baseband solutions and evolve current satellite systems to be compatible with the existing terminal infrastructure. The costs grow substantially with each unique solution that is introduced and that is expected to be integrated, interoperable, and sustained.

Over the last 25 years of providing MILSATCOM solutions, there has been an increase in capability with each successive generation of satellites. That is true for both protected and wideband communications. The Advanced Extremely High Frequency (AEHF) SATCOM program will provide secure, survivable communications to US and allied warfighters during all levels of a conflict. AEHF is a follow-on to the Milstar satellite constellation and offers 10x increase in capacity and provides 24 hour continuous coverage between 65 degrees north and 65 degrees south latitudes. AEHF satellites will be cross-linked with existing Milstar satellites to form a single, integrated and protected constellation.

The AEHF system greatly improves the available single user data rate, total satellite capacity, and the number of coverage areas while maintaining the essential features of Milstar, namely nuclear survivability, robust anti-jam performance, low probability of intercept and detection, worldwide access, and interoperability. The AEHF program enjoys a strong international partnership with Canada, The Netherlands, and United Kingdom. The first of three satellites in production has completed environmental qualification and is nearing completion of integration and test. The first AEHF satellite is expected to launch in 2010.

Figure 2. AEHF Satellite Vehicle 2 Completes Major Environmental Test at Lockheed Martin, Sunnyvale, California, 16 September 2009.

Wideband Global SATCOM (WGS) represents the workhorse of the MILSATCOM portfolio and is replacing the Defense Satellite Communications System constellation. These satellites are tremendously capable, providing X band, military Ka and Ka broadcast services. WGS employs a significant number of steerable spot beams and provides greater than two gigabits per second per satellite communications capacity. Two satellites are on-orbit providing operational capability to US Pacific Command and US Central Command. The third satellite was launched in December 2009 and will soon undergo test and check out. Three more satellites are currently in production and will complete the constellation. WGS also has an international partnership arrangement with Australia to share the resources in the constellation. This partnership goes a long way toward ensuring interoperability and compatibility between allied forces. This model could be extended to other partners and further reduce interoperability challenges facing our forces in multinational operations.

The Global Broadcast Services (GBS) system and capability is perhaps the biggest untold story about WGS. GBS was modeled after DirecTV in the mid-1990s. The concept is simple. It is a one-way transfer of data over transponded satellites to small ground apertures and receivers. This is a one-to-many broadcast to disseminate large amounts of information (intelligence products, maintenance, and supply data) quickly to many different users in real time. Capabilities for this system will continue to evolve and

leverage commercial industry standards and advances. Over 1,000 terminals have been delivered and the demand for more continues. GBS is the perfect complement to any ISR architecture due to the ability to quickly disseminate large amounts of data to large number of users in an affordable manner. In addition, GBS receiver suites operate in the military Ka band, which supports small aperture antennas (approximately 16" diameter).

In the future, it is clear that there will be a need for more coverage, capacity, and new capabilities. Current trends reveal new SATCOM capabilities are required to support the number of ISR orbits and mobile communications to small ground terminals. Full motion video and intelligence data require large data rates to support data transfer. This is anywhere between 10 to 311 megabits per platform. In addition to data rate, the sensor platform may require a dedicated satellite aperture to support operations. The amount of satellite resources consumed by a single orbit is substantial. The desire is to support 80+ orbits worldwide (in addition to providing connectivity to existing users). Clearly, the demand for satellite resources will exceed the current availability.

The need for satellites to provide mobile communications to small ground terminals at T1 (1.544 megabits per second) rates will become a reality. This requires satellites to communicate with terminal antenna apertures approximately 12 to 16 inches in diameter. The amount of satellite resources required to close these links are substantial. In the future, ground terminals will be able to transmit and receive both in the extremely high frequency and Ka frequency bands which will allow them to communicate over AEHF or WGS satellites, depending upon their need for protection. Future MILSATCOM architectures should be designed to support mobile ground terminals as the common denominator to providing communications services. Small antenna apertures facilitate easier installations of these terminals on a variety of platforms used for air, sea, and land operations.

Technology exists today to bridge the gap between current capability and future demand for service by evolving existing program of records. Increasing the number of demodulators and transmitters, employing frequency reuse, multiple beam arrays, faster processors, dual polarization, and dynamic bandwidth resource allocation schemes are examples that can be implemented in a manner that are low risk to satellite development and delivers 1.5 to 3 times the capability of the existing systems. At the same time, satellite changes need to be developed in a manner that is terminal-friendly (i.e., minor to no hardware impacts to the ground terminals if possible). At a minimum, the terminal infrastructure impacts need to be evaluated prior to making any system changes.

Expectations are high to provide solutions relevant to the way wars will be executed in the future. The use of RPAs to deliver ISR has permanently changed warfighter operations. The future SATCOM architecture requires a solution that simultaneously supports existing users and accommodates significant numbers of ISR orbits. As the infrastructure evolves and matures, it is necessary to investigate how to rapidly deploy capabilities that leverage commercial standards and hosted payloads to meet near-term or surge warfighter demands. Time-to-market is paramount in the commercial world and is difficult to achieve in the government acquisition process. A decision in 2010 would allow capability to be delivered in 2014 by the commercial industry. Commercial satellite development, production, and delivery are typically less than four years. A balance needs to be struck between timeliness, affordability, adequacy, and the ultimate goal, delivery of capability. In the end, success is achieved when capabilities are fielded to the warfighter, resulting in operational effects on the battlefield.

Figure 3. The Delta 4 rocket launches from Cape Canaveral's pad 37B on 5 December to deploy the Air Force's third Wideband Global SATCOM communications spacecraft.

Commercial communications satellites present opportunities. Intelsat, Eutelsat, Inmarsat, SES, and other satellite service providers procure and deploy many satellites in orbital slots that may (and in some cases do) provide additional communications services to theaters of interest. These companies have International Telecommunications Union approved orbital slots and plans to deploy new communications satellites. Hosting payloads is one example that would allow rapid delivery of capability and foster partnerships with commercial industry. Commercial satellites usually have varying amounts of size, weight, and power (SWaP) available and, depending upon the application, could be leveraged to provide additional capabilities. This concept is straightforward; however, there are challenges to implementing a "small" communications payload on the order of 500 to 700 pounds and 1500 to 2000 watts. The prospect to deliver capabilities in rapid fashion drives the compelling need to investigate the possibilities.

An affordable demonstration payload with the commercial industry to address military Ka airborne ISR applied information systems research and mobile communications shortfalls is

The future SATCOM architecture requires a solution that simultaneously supports existing users and accommodates significant numbers of ISR orbits.

Figure 4. An MQ-1 Predator unmanned aircraft, armed with AGM-114 Hellfire missiles,flies a combat mission over southern Afghanistan.

possible. This payload can be developed to commercial standards and demonstrated as a hosted payload on a commercial satellite. This alleviates the need to develop a military-unique satellite bus. Competition can be generated by insisting on the use of non-proprietary payload interfaces. Open standards between the satellite bus and payload can be advocated to permit and drive industry to a modular bus payload construct. Open dialogue with industry is necessary to define available SWaP and specifications to permit hosting payloads on multiple satellite types. Promoting military Ka development and gaining broader market penetration with industry and coalition partners benefits the user by reducing system costs and improving interoperability.

Commercial satellite service providers should also be encouraged to procure payloads capable of dual-band Ka operations for both commercial and military Ka radio frequency bands. These services can be flexibly-leased to the commercial market or to the military as appropriate using the military Ka-band. This would be beneficial to our forces and to our coalition partners given that existing terminal hardware or baseband could be leveraged and ground infrastructure costs could be reduced. The challenge is to persuade commercial satellite providers to adopt this type of model and for the government to be a reliable partner providing resources to evaluate and/or supplement the non-recurring efforts. This could be facilitated through a demonstration project with industry to accomplish these objectives.

Commercial providers may also benefit from deploying antenna apertures that are steerable in lieu of fixed coverage. This would provide greater flexibility to support military needs as a dual purpose designed satellite. Commercial satellites have a tremendous potential that require deliberate actions to enlist their support in satisfying the military user's demands. For example, commercial satellite provider's time to market is efficient and can supplement theater operations in a more responsive manner. Their development schedules are short enough and are considered more relevant in satisfying today's asymmetric threat. Our ability to shape the commercial market through non-recurring investments is to our advantage and warrants consideration. Today's SATCOM capabilities are critical and the increasing user demand for more SATCOM requires thorough evaluation on how commercial capabilities can be best exploited to deliver even more compatible services.

Today's asymmetrical fight has demonstrated the need to be agile in providing new capabilities. The Predator and Reaper global distributed ISR capabilities are substantial and require a robust communications infrastructure to deliver the content. These platforms enable maximum effects while loitering in theater with unblinking eyes on high-value targets. The future warfighter demands for SATCOM are increasing and will continue to grow in the future. Warfighters expect rapid, affordable solutions to meet emerging trends. Commercial SATCOM industry partnerships can enable military wideband services to be included on commercial satellites either through hosted payload opportunities or dual-band integrated operations. Influencing commercial services to be compatible with existing ground infrastructure equipment will be a significant step forward towards improving interoperability between our military and coalition partners. Properly-targeted investments today will provide the ability to shape the future and deliver responsive capabilities.

Mr. Richard D. Pino, DISES, (BS, Electrical Engineering, Florida Institute of Technology; MBA, Monmouth University, Oakhurst, New Jersey) a member of the Defense Intelligence Senior Executive Service, is the technical director for the MILSATCOM Systems Wing, Space and Missile Systems Center, Los Angeles AFB, California. Mr. Pino is responsible for all enterprise planning to deliver future MILSATCOM capabilities to support the warfighter's mission needs. Enterprise planning enables the Air Force to provide converge solutions within the Department of Defense communications framework that emphasizes interoperability, information assurance, ground architectures, and timely delivery of capability.

Mr. Pino is an acquisition professional with over 16 years providing satellite communication solutions in space and in ground platforms. Mr. Pino's experiences have encompassed each of the different phases of the acquisition lifecycle model cradle to grave. He has direct experience developing requirements, preparing program plans, contracts, conducting source selections, managing designs and developments, integration and test activities, and fielding/sustaining capabilities to the warfighter.

Mr. Pino has joint experiences having been employed by the Army, Navy and Air Force on separate assignments. Mr. Pino's program experiences include the Army's Mobile Subscriber Equipment and Army's SMART-T; the Air Force's Milstar II, Advanced Extremely High Frequency, Transformational SATCOM; and the Navy's Extremely High Frequency SATCOM Program and Navy Multiband Terminal.

Steps Towards International Space Situational Awareness

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In a previous issue of *High Frontier*, several articles eloquently recounted challenges that were faced in Air Force Space Command's (AFSPC) Schriever V Wargame. During the wargame, participants from the US military alongside coalition partners and representatives from myriad US government agencies worked through a demanding scenario to pursue common space objectives. While the wargame uncovered many challenges, one stands out as perhaps the most important for the future of US military space activities worldwide. We are referring to data sharing with allied and coalition partners. That same issue of *High Frontier* included an insightful commentary by The Honorable Terry Everett, former representative from Alabama, "Building the Political Consensus to Deter Attacks on Our Nation's Space Systems," calling for "exquisite transparency." He highlighted the issues associated with deciding who collects the necessary data (and under what auspices) and determining not only what data to share, but also how to share it.[1] These obstacles are reflective of current international and interagency realities that the men and women of the Joint Space Operations Center (JSpOC) face daily.

For example, on 10 February 2009 two satellites collided in low Earth orbit over Siberia. The collision, which involved a defunct Russian military communications satellite and a US commercial communications satellite; and the resulting cloud of debris, which is tracked by a network of US military and civilian sensors, demonstrated to the international space community that it must find a way to coordinate information about operations in space. In the aftermath of the collision, the JSpOC began notifying an increasing number of commercial and foreign satellite owner-operators of potential collisions involving their spacecraft. However, this effort has experienced many of the difficulties with data sharing encountered during the Schriever V Wargame and described by Mr. Everett.

Given the findings of Schriever V and the effects of the Iridium-Cosmos collision, it seems appropriate for us to write an article about how data sharing challenges might be overcome in a critical space mission area—space situational awareness (SSA); and in particular how SSA can be pursued and shared internationally. Our intent is to review the fundamental attributes of international SSA and to describe how they relate to the current capabilities of the JSpOC. Ultimately, we believe that the JSpOC is uniquely positioned to serve as the core of a future international SSA center and that with some enhancements could perform that function quite effectively.

SSA is an exceedingly complex concept; yet it sits at the cornerstone of nearly all JSpOC operations. Joint Publication 3-14, *Space Operations*, defines SSA as:

> The requisite current and predictive knowledge of the space environment and the operational environment upon which space operations depend—including physical, virtual, and human domains—as well as all factors, activities, and events of friendly and adversary space forces across the spectrum of conflict.[2]

Given that a significant portion of space activity is conducted by international actors, achieving the degree of predictive knowledge necessary to obtain SSA requires that information be given to, and be received from, international partners. There are certainly many ways to go about this. For example, even as we write this article, a group of commercial space companies are forming a partnership to address perceived short-comings with the current level of international data sharing. Three major satellite operators: SES, Intelsat, and Inmarsat have established a multi-national commercial collective partnership, the Space Data Association (SDA), to increase data sharing between global commercial space operators as a way to help close the gap between the data they desire and the data the US is currently able to provide.[3]

While the SDA represents an important evolution on how international space data can be shared, it seems that achieving true SSA requires a broader set of capabilities than organizations like the SDA currently possess. From our perspective, this suggests that the most effective way to achieve international SSA would be to create an international center for SSA.

Establishing such a center would not be a simple task. Fortunately, some substantial thought has already been given to identifying the essential elements that must be included in, and key steps that must be taken to establish, an international SSA

While the SDA represents an important evolution on how international space data can be shared, it seems that achieving true SSA requires a broader set of capabilities than organizations like the SDA currently possess.

center. At the 2009 US Strategic Command (USSTRATCOM) Strategic Space Symposium, Mr. Nick Johnson, chief scientist for orbital debris at the National Aeronautics and Space Administration, provided a thought-provoking presentation that outlined the fundamental elements of an effective international SSA capability.[4] While this list may not be all inclusive, we think it provides an excellent framework for conceptualizing what is necessary to achieve international SSA and thus for establishing an international SSA center.

Mr. Johnson's first fundamental element of international SSA is *a firm technical foundation for the information necessary to achieve SSA*. By this, Mr. Johnson means that we must define the essential parameters that must be known by space decision-makers in order to make timely and accurate decisions. For instance, it may not be sufficient for a satellite operator to know that a satellite has a potential conjunction with another object. In order for the operator to take action to avoid that collision, he may also need to know such information as: the direction from which the conjuncting object is approaching; the size and direction of the maneuver that would be required to prevent the collision; the closure rate of the conjuncting object; and whether or not the conjuncting object is expected to maneuver before the conjunction. Mr. Johnson suggests before we pursue any other aspect of international SSA, we must define a common set of data, its format, and the means to share it, in order to answer these types of questions for satellite operators.

The lack of an existing standard for SSA data has certainly had implications for the JSpOC. Currently, the JSpOC operates on multiple disparate mission systems, many of which use unique data formats. Complete processing of SSA data requires JSpOC operators to manually manipulate and transfer data between multiple computer systems across a range of classification levels. Further, the lack of data standards has hindered the JSpOC's ability to develop broad declassification guidance. As a result, a significant percentage of SSA data, once processed within the JSpOC, becomes classified. This, in turn, has complicated the JSpOC's ability to share processed information with international partners.

As Mr. Johnson suggests, what is needed to rectify this is a firm technical foundation to define the data format, accuracy, timeliness, and exchange standards that permit data to be transmitted to, and received from partner nations and/or international commercial enterprises. Recognizing that safeguarding data is driven by both national and commercial interests, this technical foundation must also incorporate security measures in such a way that they protect user information while presenting the minimum obstacle possible for sharing that information. A well-designed technical foundation could help the JSpOC share information to achieve the international SSA that space decision makers at all levels require.

Mr. Johnson's second fundamental element is *an interactive flow of data and information*. For this element, Mr. Johnson described the need to be able to take in, as well as send out SSA data. Currently, the US provides the majority of SSA information to global space operators. Thought of another way, there is a rather large diameter pipeline of data flowing out of the JSpOC, but the diameter of the pipeline for information coming in from international sources, although growing, is comparatively small. This imbalance sub-optimizes the quality of SSA data available to the JSpOC and works to undermine the cooperative relations that must exist to achieve genuine international SSA.

Today, the primary method by which the JSpOC shares information with international partners is through the Commercial and Foreign Entity (CFE) program.[5] The CFE program was established to give USSTRATCOM a formal means to engage with commercial and/or foreign space operators. Since February 2009, the JSpOC has steadily expanded its capacity to screen spacecraft covered by the CFE program, and is currently screening all maneuverable satellites daily for potential collisions.[6] In the past the JSpOC only let commercial owner-operators know that their satellite would be conjuncting with a "known object," giving them information on when it would occur, and telling them what the miss distance would be. Consistent with the need to protect certain aspects of US space operations, JSpOC personnel recently started providing satellite operators with the names—as applicable—and the satellite catalog numbers of the conjuncting objects. The JSpOC is currently working towards including information about the level of error introduced by the quality of the orbital data used to make the prediction, and supplying the actual data used to make the prediction as well. Although the program currently places considerable emphasis on screening satellites for conjunctions, CFE activities also need be the venue to exchange information on launch profiles, early orbit plans, all on-orbit operations, and end-of-life activities.

Although the CFE program has allowed the JSpOC to substantially expand communication and information flow with international partners, there are still things that can be done to improve information sharing. First, the existing policy prohibiting the use of owner-operator satellite position data to update the master catalog of orbiting space objects (i.e., "the space catalog") should be amended. Currently, the JSpOC is permitted to use owner-operator data to perform screenings for potential collisions, but it cannot use owner-operator data to help maintain the catalog. Using owner-operator data would not only give the JSpOC access to more accurate data than it could get from its own space surveillance network (SSN) assets, but it would also allow the JSpOC to concentrate SSN taskings on those objects for which we do not have owner-operator information. Second, once it is able to use data from operators, the JSpOC will need to modify its systems to be able to ingest and process it automatically. Currently, JSpOC operators need to manually input any external data. Therefore, to reduce personnel requirements and to minimize chances for operator error during data handling, JSpOC systems must be able to automatically receive and translate owner-operator information. Finally, the JSpOC's partners should be encouraged to pursue consent to share a broader set of data with the JSpOC. For example, the JSpOC could more effectively support our CFE partners' launch and on-orbit operations if they provide us their planned launch profiles and satellite maneuver burn plans. These three actions would go far to institutionalize data sharing as a key part of international SSA.

Mr. Johnson's third fundamental element of international SSA is to ensure that we *establish viable domestic solutions before entering the international arena*. Mr. Johnson's point here is that the US must have broad agreement on how it will pursue and achieve SSA within its own domestic space enterprise before it can realistically pursue SSA in concert with international partners. From his perspective, if the collective of US domestic government, academic, commercial, and scientific communities do not have a common aggregate approach to SSA and data sharing, then the US will face significant difficulties as it seeks to partner with international entities.

Although the JSpOC has room for improvement regarding coordination within the domestic US space enterprise, it has mature organizational practices that have proven themselves both in day-to-day and contingency operations. Specific examples include the successful characterizations of North Korea's Taepo Dong 2 launches, the accurate tracking of the Chinese SC-19 antisatellite weapon debris, and the pin-point targeting solution developed for the shoot-down of USA-193 during Operation Burnt Frost. These types of procedures, and the relationship the JSpOC has built with many stake holders of the domestic space enterprise, can be leveraged to help forge a domestic consensus on SSA, which can then serve as the foundation for international SSA.

The fourth of Mr. Johnson's foundational SSA elements is a logical extension of his third element. He suggests the US needs to pursue *bilateral agreements before multilateral agreements*. Mr. Johnson suggests that as the US pursues international SSA, it should begin with a solid foundation based on strong bilateral agreements. Bilateral agreements, he argues, are easier to achieve and execute and, as such, could maximize information sharing in the near term. Further, the lessons identified in bilateral arrangements could significantly facilitate the transition to multilateral agreements as the US and other nations expand data sharing to a larger group of international partners.

Over the past year, the USSTRATCOM, AFSPC, and the Joint Functional Component Command for Space have had significant achievement in this area. Under the CFE program, the JSpOC has entered into 19 bilateral agreements to share SSA information. An additional 32 commercial and foreign entities receive SSA information under bilateral partnership, even though they have not established formal agreements with the JSpOC. As the JSpOC continues to expand its CFE relationships, there will likely be a time when it would be more efficient or effective to establish multilateral agreements vice bilateral agreements. At that point, the JSpOC will be well-positioned to apply the lessons learned from both current and future bilateral agreements to ensure multilateral agreements serve not only our nation's interests, but also the interests of the global space community.

Flexibility is Mr. Johnson's fifth fundamental element of international SSA. History teaches that entities enter into agreements for a variety of reasons; and very rarely are those reasons common among all the parties of the agreement. Inevitably, this reality leads to competing demands, priorities, and interests among the parties of the agreement. It is reasonable to believe that data sharing for international SSA will be no different. Therefore, to accommodate potential competition and conflict in international SSA, participating entities will need to be flexible. Or said another way, they will need to engage in some level of compromise. It is not likely that any one entity, regardless of its relative role in international SSA would be able to mandate all aspects of an international SSA architecture.

The JSpOC recognizes this. And despite being the largest single contributor to achieving SSA, the JSpOC understands that it may be required to modify its current positions on many matters. The JSpOC may find that some of its existing ways of doing business may not foster the cooperation necessary to promote international SSA. For example, current US policy prohibits sharing certain unclassified conjunction assessment data with partners even though this data might be very useful in helping resolve potential close approaches. Perhaps the time has come to reevaluate policy.

Mr. Johnson's final element is *personal relationships*. In Mr. Johnson's view, achieving true international SSA cannot be done bureaucratically. Communication between organizations, he argues, will have to be based on personal relationships. Only communications between individuals will foster the trust and coordination necessary to achieve international SSA. Over the past year, the JSpOC has issued nearly 200 satellite close approach warnings to operations centers around the world. And in doing so, its operators have begun to develop those relationships with counterparts that will likely facilitate the communication necessary to resolve future problems. In fact, during our time in the JSpOC, we have been able, on more than one occasion, to avert problems primarily because people who knew each other were able to pick up a phone and work through the issues at hand.

Because of the high turnover inherent in military organizations, however, it can be difficult to form and sustain close personal relationships with externals partners. To help mitigate this, the JSpOC is in the process of adding 24 permanent civilian orbital analyst positions. Once hired, these individuals will help cultivate and preserve the long-term personal relationships so necessary for cooperation.

Our assessment is that Mr. Johnson's six elements: *a firm technical foundation; an interactive flow of data and information; establishment of viable domestic solutions; bilateral before multilateral agreements; flexibility;* and *personal relationships* are largely on target. The experiences of the JSpOC have provided—and continue to provide—a unique insight and perspective on SSA. If the global community of space operators chooses to pursue an international SSA operations center, the process should be entered into—and carried out—deliberately, with strong consideration given to Mr. Johnson's recommendations.

As we head down that path, it seems to us that, with some modest improvements and upgrades, the JSpOC could easily serve as the nucleus for an international SSA center. Although it does not yet have *a firm technical foundation* or the capability for *a robust interactive flow of data and information*, the JSpOC will get these elements over the next few years as part of the

JSpOC Mission System (JMS). JMS, a billion-dollar acquisition program, will fundamentally change the way the JSpOC performs not only SSA, but command and control of space forces, *writ large*. The first spiral, or installment, is scheduled for delivery in late spring 2010 and could serve as the basic architecture, or *technical foundation*. Over the next several years, subsequent installments will add modules to facilitate the *interactive flow of data and information*.

Even with the delivery of these fundamental elements, there are issues remaining to be addressed if the US government does take the lead in establishing an international SSA center with the JSpOC as the core. One area that may need to be addressed is the role of the military in international SSA. Over the past half century, the demographic of satellite operators has transformed from one dominated by national security actors to one in which militaries and intelligence agencies own less than a quarter of orbiting assets. In fact, according to our data, since 1957 commercial and civil owner-operators have grown to account for more than 75 percent of on-orbit operational satellites. The composition of personnel within the international SSA center needs to reflect this shift.

Another facet of military participation in an international center is the issue of trust. Military organizations, in attempts to protect sensitive methods, sources, and operations, rarely encourage openness and cooperation with non-military agencies. Although implemented for valid reasons, these practices can result in a general sense of distrust from commercial, civil, and academic organizations. Although the CFE program is not fully mature, it has the potential to help overcome this distrust. Operators on the JSpOC floor are working with operators literally around the world helping to make the space domain a safer place. Activities like these will go a long way to building the personal relationships that engender feelings of trust.

Achieving international SSA is a difficult but achievable goal. Mr. Johnson's six ideas are valuable to keep in mind as we work towards that end and there are a variety of paths we can take towards an operations center that would help us achieve that goal. The challenges experienced by the participants in the Schriever V Wargame, and many other international exercises, are formidable. If we apply the lessons learned from those scenarios and our real-world operations we will be closer to achieving the goal of international SSA. Regardless of the elements we choose to incorporate into an international SSA operations center or the steps we take to get there, the immediate next step is for the JSpOC to continue expanding its on-going international data sharing. As the JSpOC has started to take this step it has learned that SSA is not a zero-sum endeavor. The information we share with our international partners helps them to better inform us of their intentions and future operations so we can shape our decisions based on accurate and timely information. Ultimately, this is a crucial component of international SSA.

Notes:

[1] Former Representative Terry Everett, "Building the Political Consensus to Deter Attacks on Our Nation's Space Systems," *High Frontier* 5, no. 4 (August 2009): 3-8.

[2] Joint Publication 3-14, *Space Operations*, 6 January 2009, GL-10.

[3] Space Data Association, "About SDA," http://www.space-data.org/sda/index.php.

[4] Mr. Nick Johnson, NASA chief scientist, Orbital Debris, prepared remarks, US Strategic Command Strategic Space Symposium, Omaha, Nebraska, 2 November 2009.

[5] USSTRATCOM recently changed the name of the CFE program. It is now SSA Sharing.

[6] As of 1 January 2010, the JSpOC is screening all active satellites for potential collisions.

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Colonel Boltz' career has included operational assignments in satellite command and control, space lift, and space support. He has held staff positions at the headquarters of: Air Force Space Command, US Air Forces Europe, and US Strategic Command. Colonel Boltz commanded the 17th Test Squadron and has been selected to command the 30th Space Wing.

Colonel Boltz was the top graduate at both the AFIT space operations masters program and the US Air Force Space Tactics School. He finished Air Command and Staff College as a distinguished graduate, and also has degrees from the School of Advanced Air and Space Studies and the National Defense University. Colonel Boltz was a senior executive fellow at Harvard University's Kennedy School of Government and completed the US Air Force Enterprise Leadership Seminar at the University of Virginia's Darden School of Business.

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Are We Experiencing a Global Navigation Satellite System Insurgency?

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The US has, for more than a decade, enjoyed an overwhelming monopoly in the area of global space-based radio navigation. Global Positioning System (GPS), which started as a US military system has become a global phenomenon. Use of GPS has become amazingly widespread across a variety of public and private sectors and dependence on it is only projected to grow. In fact, because of the growing popularity and dependence on radio navigation from space, other nations are beginning to develop their own independent Global Navigation Satellite Systems (GNSS) and/or augmentations. The European Union, for example, is building a space-based radio navigation system of 27 satellites and appropriate ground infrastructure called Galileo. Europe's intention is to break away from use of the US system and build their own, that purportedly surpasses GPS in the use of cutting-edge technology, performance and capability. Europe is not alone. China, India, and Japan are all investing in GNSS and Russia is reinvigorating their GNSS known as GLONASS. So, why would Europe (and others) decide to build a multi-billion euro system when they can use GPS free of direct user fees with performance guaranteed by the US government? Should these initiatives be viewed as a GNSS insurgency?

The Department of Defense (DoD) defines an insurgency in Joint Chiefs of Staff Publication 1 as, "An organized movement aimed at the overthrow of a constituted government through the use of subversion and armed conflict." The overthrow of governments is a far cry from the ending of a GNSS monopoly, and these nations are not using subversion or armed conflict. The US Army's Field Manual (FM) 100-20, Military Operations in Low Intensity Conflict provides an expanded definition that may be more applicable. FM 100-20 (4:2-0) defines an insurgency as:

> An organized, armed political struggle whose goal may be the seizure of power through revolutionary takeover and replacement of the existing government. In some cases, however, an insurgency's goals may be more limited. For example, the insurgency may intend to break away from government control and establish an autonomous state within traditional ethnic or religious territorial bounds. The insurgency may also only intend to extract limited political concessions unattainable through less violent means.

Drawing from both definitions, a movement can be considered an insurgency if it involves seizure of power from an existing government by unlawful means. Certainly Europe, China, Russia, and the other nations are seeking to reduce their dependency on GPS. However, they are not using unlawful means. Each nation is coordinating their systems through the International Telecommunications Union, and other avenues, to bring legitimacy to their systems.

Even though we will not label the sea state change in global navigation as an insurgency, it will still be informative to discuss why it is occurring. There are several reasons why there is a push by so many nations to have their own independent GNSS. The first reason is sovereignty. Satellite navigation (GPS in this case) has become indispensible across multiple sectors of society around the globe. Not only is it a crucial part of the US' and other nations' critical infrastructure, satellite navigation is also vital to commerce, communication, farming, defense, emergency response, recreation, and ground and air transportation. Here is where sovereignty becomes important.

No nation wants to have to rely on another nation to provide a service upon which their commerce, communications, and transportation are critically dependent. Nation states may be especially concerned if a critical segment of their infrastructure is perceived to be operated and controlled by another nation's military. It is ultimately an issue of trust. While the US is highly regarded in most of the world, and while the US government has guaranteed the quality of the GPS position, navigation, and timing (PNT) service through the standard positioning service performance standard (SPS PS), trust of the motives and actions of the DoD, which is perceived as the ultimate controlling authority of GPS in much of the world, cannot be presumed on the part of other nations. So, several nations are seeking to reduce their dependence on GPS.

A second reason why there are more GNSS being pursued is nationalism. We see this in the European Union (EU), Russia, India, and China. All four systems, Galileo, GLONASS, the Indian Regional Navigation Satellite System (IRNSS), and COMPASS are, in part, being pursued for nationalistic pride. Galileo, especially, is one of several high-tech, collaborative pursuits in the EU. Galileo is seen in the EU as an opportunity for Europeans to prove they can compete with the US. Europeans see Galileo as an opportunity for the EU to equal or surpass US capabilities in the area of GNSS, much as Airbus Industries has proven to be a significant competitor to the only remaining US commercial aircraft manufacturer, Boeing. The resurgence of the Russian GLONASS system might also be attributed to nationalistic pride. The aggressive marketing of the Europeans may have triggered the Russians to pursue the additional funding and the political backing needed to keep their GNSS competitive. COMPASS is also partly being pursued for nationalistic pride. We see China striving for recognition as a world power in several areas, and rightly so. China is now a global economic power, their military is growing in stature and they are seeking recognition as a space power. This is evidenced by their growing space infrastructure, launch capability, and their anti-satellite demonstration. COMPASS contributes to their pursuit of space power and provides independence from the US for satellite navigation. Furthermore, since the Chinese may feel they were snubbed by the Europeans by not being allowed to

fully partner on Galileo, COMPASS is an opportunity for the Chinese to prove that they would have been a strong partner.

In the face of this GNSS power struggle, the US has not exactly formed a foreign GNSS strategy. We do however, have an overarching national PNT strategy (PNT being somewhat synonymous with GPS in this case). As part of the PNT strategy, the US is engaging the nations of the world to further our national objectives in the area of spaced-based radio navigation. This direct engagement takes place in several forms. First, the US actively participates in many domestic and international conferences on space and GNSS. In the US, the primary forum is the Institute of Navigation (ION), whose satellite division holds three technical conferences per year, including ION GNSS, the largest annual gathering of worldwide satellite navigation experts. We also participate in international conferences such as Europe's Navigation Conference and the Munich Satellite Navigation Summit. At these conferences the US openly provides status and performance reporting of GPS, the status of modernization efforts and any current issues of interest to the satellite navigation community. For example, the DoD has spent a significant amount of time discussing a 2008 General Accounting Office report on the sustainment of GPS and its implications for global users, and the discussions which were published in open fora.

In addition to conferences, the US also participates in a United Nations sponsored forum known as the International Committee on GNSS (ICG). In its resolution 63/90 of 5 December 2008, the United Nations General Assembly noted that the ICG had been established on a voluntary basis as a forum to promote cooperation, as appropriate, on matters of mutual interest to its members related to civil satellite-based PNT and value-added services; cooperation on the compatibility and interoperability of global navigation satellite systems; and to promote their use to support sustainable development, particularly in developing countries.

The US is also actively engaged in bilateral coordination with each GNSS provider nation. For example, the US recently completed a bilateral discussion with China in Sanya, Hainan, China. There are several outcomes of our global engagement thus far. First, we have a signed agreement with the European Union on GPS/Galileo radio frequency and national security compatibility. Additionally, we have developed a set of principles in our bilateral and multilateral negotiations that each nation should embody when providing space-based navigations services. The objective of each bilateral is to reach agreement between GNSS provider's systems on the key principles of radio frequency compatibility (RFC) and interoperability, while at the same time promoting good will and transparency among the GNSS providers. The principle of compatibility refers to the ability of global and regional navigation satellite systems and augmentations to be used separately or together without causing unacceptable interference or other harm to an individual system or service. The principle of interoperability refers to the ability of global and regional navigation satellite systems and augmentations and the services they provide to be used together to provide better capabilities, at the user level, than would be achieved by relying solely on the open signals of one system. The third and final principle is transparency. Transparency refers to the openness of GNSS providers in the area of providing publicly accessible interface control documents (ICDs) and public commitments of performance such as the GPS SPS PS.

A further result of our global engagement in the area of interoperability has been the establishment of a set of common "open service" signals for all GNSS users. Open service signals are those made available free of direct user fees and with public signal characteristics with some level of guaranteed performance. The GPS C/A code signal on the L1 frequency is an example of a current open service signal. There are also US open service signals on the L2 and L5 frequencies. In the area of compatibility, the nations pursuing GNSS have also been seeking agreement on the use of "authorized" signals. Authorized signals are those signals whose access is controlled by the operating nation. The US P(Y) code and M-Code signals are examples of authorized signals.

The pursuit of independent GNSS by the EU, Russia, Japan, India, and China, is not a global navigation insurgency, although it does challenge the monopoly GPS has enjoyed worldwide. Each nation is legitimately pursuing nationalistic goals and seeking to guarantee their own sovereignty. US engagement is needed to ensure that each system is compatible with other systems and the open signals are interoperable. US engagement with other GNSS providers will continue and, in all likelihood, increase as other nations get closer to achieving full operational capability. This engagement will be accomplished through participation in domestic and international conferences and multilateral and bilateral discussions. The US has been and will continue to be superb stewards of GPS and the navigation and timing service it provides to the world. Navigation and timing accuracy and availability for the entire world has never been better and will further improve as GPS modernization efforts continue to be brought on-line and other nations deploy synergistic capabilities. So while there is competition and there will of course be challenges, global navigation users will benefit, and yes…the future is bright for PNT.

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Legal Considerations of International Space Operations

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As the newly assigned staff judge advocate for Air Force Space Command, and with no previous experience in the command, I was immediately impressed by the magnitude of the command's mission and responsibilities. There is no question that unimpeded operations in space are vital to the US and the international community (consider the world's reliance on the Air Force operated global positioning system).

It is equally apparent that the potential for interference with our space operations exists from a variety of sources. Unfortunately, "intentional interference with space-based intelligence, surveillance, reconnaissance, navigation, and communication satellites, while not routine, now occurs with some regularity."[1] Apart from interference caused by the intentional act of a state or entity, the increasingly cluttered operating environment poses its own risks from the number of states and commercial entities that operate in space. The space domain is an expanse where operations and conduct must be ordered—there are over 19,000 "trackable" objects, and the number is growing.[2]

As I considered how the US would identify the source of particular interference and, if attributable, examine the remedies available to us for the interference, the analytical framework that follows took shape. The framework is deceptively straightforward, because no part of what follows is straightforward in practice.

No Sovereignty in Space

A state cannot "own" space. The 1967 agreement commonly referred to as the Outer Space Treaty provides that "outer space, including the moon and other celestial bodies,[3] is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[4] Article I of the treaty recognizes that the exploration and use of outer space shall be the province of all mankind, and outer space shall be free for exploration and use by all states without discrimination of any kind. Perhaps exactly because states enjoy free access to and use of space, the domain needs a common, ordered approach to activity there.

Ordering Conduct in Space

The Outer Space Treaty establishes that a state party to the treaty on whose registry an object is launched into outer space is carried "shall retain jurisdiction and control over such object" while in outer space.[5] In the event of an incident, a state party to the treaty that launches such an object into outer space "is internationally liable for damage to another state party to the treaty" by such object.[6]

Two other important sources regulating state conduct are agreements signed by the US over thirty years ago. The Convention on International Liability for Damage Caused by Space Objects noted that, despite precautionary measures taken by states,[7] damage may occur. Under Article III of the convention, a state is liable for damage caused to a space object of another state only if the damage is due to its fault or the fault of persons for whom it is responsible—in other words, liability appears to be based on a simple negligence standard.[8] If damage occurs, a state which suffers the damage may present a claim for compensation to the offending state through diplomatic channels.[9] If no settlement is reached through diplomatic negotiations within one year, the parties shall establish a Claims Commission if either party requests one,[10] and the convention prescribes the commission process.

The Convention on Registration of Objects Launched into Outer Space was based on the belief that a mandatory system of registering objects in space would assist in their identification.[11] Article II of the convention provides that a state that launches a space object into Earth orbit or beyond shall register the object in a national registry maintained by the state. Article IV requires each state of registry to furnish specific information "as soon as practicable" to the secretary general of the United Nations: name of the launching state or states; an appropriate designator of the space object or its registration number; the date and territory or location of launch; basic orbital parameters; and, the general function of the space object.

Event Identification - The Importance of Attribution

Potential legal remedies and other state response options are theoretical without the capability to identify the cause of a space event (interference with, degradation, or destruction of a space object). How important is the capability to attribute an event to someone or something?

> [Space situational awareness] SSA *is crucial* to accurate determination of the space system failure, whether from environmental effects, unintentional interference, or an adversary attack, *allowing decision makers to determine the appropriate response* [emphasis added].[12]
>
> Before we can talk about providing space protection, we need to understand what is going on up there. We need to have the tools in place to establish what is being launched, what the capabilities are, the intent, and ultimately attribution. Once we have attribution, we can determine the options the US government has to deter, dissuade or stop someone if they have started doing these types of things. As a result of the Chinese antisatellite testing, and since we were able to attribute (the launch) to them, China is receiving diplomatic pressure from around the world. *"There are tools available outside the military, such as diplomatic pressure, that are available for our country to use; but without attribution, you can't use a single one of them"* [emphasis added].[13]

How challenging is the environment?

> Space traffic growth is both a challenge and a concern. In 1980 only 10 countries were operating satellites in space. Today, nine

> countries operate spaceports, more than 50 countries own or have partial ownership in satellites and citizens of 39 nations have traveled in space. In 1980 we were tracking approximately 4,700 objects in space; 280 of those objects were active payloads/spacecraft, while another 2,600 were debris. Today we are tracking approximately 19,000 objects, 1,300 active payloads, and 7,500 pieces of debris. In 29 years, space traffic has quadrupled.[14]

The US will have no meaningful response to an event if it cannot identify who caused it. SSA is a much broader subject than the issue of attribution, which we may consider to be a product of effective SSA. A general appreciation of SSA is important, though, and Air Force doctrine is the best place to start: "SSA is the result of sufficient knowledge about space-related conditions, constraints, capabilities, and activities—both current and planned—in, from, toward, or through space."[15]

How do we improve SSA and, with it, attribution? In significant part, through the Joint Space Operations Center (JSpOC) at Vandenberg AFB, California. The JSpOC's SSA Operations Cell maintains a current computerized catalog of all orbiting man-made objects, charts preset positions, plots future orbital paths, and forecasts times and general location for significant man-made objects reentering the earth's atmosphere.[16]

SSA will be further enhanced through improved capabilities such as the launch of the Space-Based Surveillance Satellite (SBSS), and through cooperative arrangements such as the commercial and foreign entities (CFE) effort.

SBSS Block 10 is an optical sensing satellite that will operate in a near-polar Sun-synchronous orbit.[17] SBSS will search for, detect, and track man-made space objects in deep space, collecting both metric observations and photometric space object identification data in support of space surveillance.

The CFE effort is an SSA-sharing service between the US government and non-US government entities with the goal of improving satellite safety of flight operations. Congress authorized a pilot program that allowed the secretary of defense to provide space surveillance data support to non-US government entities (state governments, US commercial entities, foreign governments, and foreign commercial entities, among others).[18] Although the pilot program expired on 30 September 2009, the National Defense Authorization Act for fiscal year 2010 modified the program and made it permanent.[19]

Effective SSA provides information that can help states prevent adverse events, and support state efforts to assess the cause of events that do occur. Air Force doctrine document 2-2.1 recognizes that space system information allows the US to, among other things, characterize space capabilities operating in the space environment, prevent inadvertent collisions between man-made objects, predict and defend Air Force space systems from attack, and determine the cause of space system failure—whether from environmental factors, unintentional interference, or adversary attack—to allow decision makers to formulate an appropriate response.

Response Options

According to the 2006 National Space policy:

> The US considers space systems to have the right to pass through and peacefully operate in space without interference … the US views purposeful interference with its space systems as an infringement on its rights, and furthermore considers space capabilities, including the ground and space segments and supporting links, as vital to its national interests.[20]

Available response options will be determined by the identity of the actor.

Intentional or Hostile Act by a State

Diplomatic responses, including claims. Attribution matters in the political realm, although a lesser degree of certainty may be demanded than would be required to support a military response. A state may choose not to respond at all, particularly if doing so would reveal information the state does not want its adversaries (and others) to know. More challenging is the prospect of recovering compensation for damages incurred. If, for example, a US satellite is damaged in space, the US could seek compensation through the liability convention mechanism, through the courts or administrative forums available in the offending state,[21] or through diplomatic pressure. The liability convention has been used only once: when debris from the Soviet satellite, Cosmos 954, landed in Canada. Canada sought compensation for recovery efforts and other satellite expenses, and the Soviets paid three million Canadian dollars (the claim was for $6,041,174.70).[22] The Canadian claim was grounded in large part on the liability convention, but the settlement protocol did not refer to the convention and the Soviets did not admit liability.[23]

Trade, economic, and other sanctions. A state may pursue a range of sanctions for another state's conduct. The political decision to impose economic sanctions, alone or with other states, is a significant step that must rest on a high degree of proof that attribution has been correctly assigned.

Military response. The standing rules of engagement (SROE), issued by the chairman of the Joint Chiefs of Staff, provide guidance on the application of force for mission accomplishment and the exercise of self-defense.[24] The SROE have unclassified and classified components. The unclassified rules on the inherent right and obligation of self-defense permit the US to defend itself with force in response to an attack or other use of force against the US (in space and elsewhere). The threshold question is: who attacked us? We must be able to first attribute the attack to a particular state (or states), even if we decide not to respond. Supplemental implementing measures may define the degree to which we must establish positive identification before executing a military response.[25, 26]

Intentional or Hostile Act by Non-State

US response options for action by a non-state actor, individual or entity, are limited and attribution is even more difficult. A military response is unlikely, although not foreclosed by the SROE. In practice, the available options will rest on jurisdiction—as a practical matter, whether the offender is in the US or another state.

US has jurisdiction. Civil action for monetary damages could be pursued, although the offender may not have sufficient assets to satisfy a judgment. Criminal prosecution may be an option, for example under 18 US Code § 1367 for interference with the operation of a satellite. Attribution must be proven beyond a reasonable doubt.

US does not have jurisdiction. US options are extremely lim-

ited. Diplomatic pressure may be brought to bear against a state from which the non-state actor operated to take action against the perpetrator.

Negligent Act

US response options will include a diplomatic component, and may include a claim for compensation. As described above, if a US object is damaged in space, for example, we could seek compensation through the liability convention mechanism, through the courts or administrative forums available in the offending state,[27] or through diplomatic pressure.

Conclusion

Space activity, from launch to operation, is technically and scientifically complex. Shaped by a largely untested legal regime and influenced by political realities, the relationships between states and entities that are active in space are equally complex. This article presented a basic framework to examine events and relationships in an environment where situational awareness, problem avoidance, attribution, and response are constant challenges.[28]

Notes:

[1] Statement of Gen James E. Cartwright, then Commander, US Strategic Command, before the House Armed Services Committee (Washington, DC: 21 March 2007), 6, http://armedservices.house.gov/pdfs/FC032107/Cartwright_Testimony032007.pdf.

[2] Statement of Lt Gen Larry James, Commander Joint Functional Component Command for Space, before the House Committee on Science and Technology (Washington, DC: 28 April 2009), 2–3, http://gop.science.house.gov/Media/hearings/space09/april28/james.pdf.

[3] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the moon and other celestial bodies, 27 January 1967, 18 UST 2410, TIAS 6347, 610 UNTS 205 [Outer Space Treaty] (US ratification deposited on 10 October 1967).

[4] Ibid., Article II.

[5] Ibid., Article VIII.

[6] Ibid., Article VII.

[7] Convention on International Liability for Damage Caused by Space Objects, 29 March 1972, 24 UST 2389, TIAS 7762, 961 UNTS 187 [Liability Convention] (US ratification deposited on 9 October 1973).

[8] Compare this to Article II of the Liability Convention: "A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight."

[9] Liability Convention, Article VIII, paragraph 1; and Article IX.

[10] Ibid., Article XIV.

[11] Convention on Registration of Objects Launched into Outer Space, 14 January 1975, 28 UST 695, TIAS 8480, 1023 UNTS 15 [Registration Convention] (US ratification deposited on 15 September 1976). The final paragraph of the preamble to the Registration Convention states:

> Believing that a mandatory system of registering objects launched into outer space would, in particular, assist in their identification and would contribute to the application and development of international law governing the exploration and use of outer space.

[12] Air Force Doctrine Document (AFDD) 2-2.1, *Counterspace Operations*, 2 August 2004, chapter 3, 19–20.

[13] Statement of Gen Kevin P. Chilton, then the commander, Air Force Space Command, before the House Armed Services Committee (Washington, DC: 23 March 2007), reprinted in SSgt Monique Randolph, "Senior Leaders Testify About Air Force Space Program," Secretary of the Air Force Public Affairs, 6 April 2007, http://www.afspc.af.mil/news/story.asp?id=123047864.

[14] Statement of Lt Gen Larry James, supra note 2.

[15] AFDD 2-2.1, *Counterspace Operations*, chapter 1, 2.

[16] USSTRATCOM Space Control and Space Surveillance Fact Sheet (25 February 2008), 3, http://www.stratcom.mil/files/STRATCOM_Space_and_Control_Fact_Sheet-25_Feb_08.doc.

[17] Air Force Space Command, Space Surveillance Network (SSN) Site Information Handbook (24 October 2007), 148, https://wwwd.my.af.mil/afknprod/ASPs/docman/Process/ProcessDOCFunctions.asp?DocID=6711015&Function=ViewDocument&FolderID=OO-OP-SP-80-16&Filter=OO-OP-SP-80.

[18] Section 2274 of Title 10, US Code.

[19] *National Defense Authorization Act for Fiscal Year 2010*, Public Law 84, 111th Cong., 1st sess. (28 October 2009) Section 912, http://www.govtrack.us/data/us/bills.text/111/h/h2647enr.pdf.

[20] Statement of Gen James E. Cartwright, supra, 12–13.

[21] The Liability Convention does not prevent States or private individuals from seeking other means of recovery. Liability Convention, Article XI, para 2 provides: "Nothing in this convention shall prevent a state, or natural or juridical person it might represent, from pursuing a claim in the courts or administrative tribunals or agencies of a launching state."

[22] Canada, Claim Against the USSR for Damage Caused by Soviet Cosmos 954, 18 ILM 902 (1979).

[23] Canada-USSR. Protocol on Settlement of Canada's Claim for Damages Caused by Cosmos 954, 20 I.L.M. 689 (1981).

[24] Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3121.01B, *Standing Rules of Engagement/Standing Rules for the Use of Force for US Forces*, 13 June 2005, Enclosure A, para 1a.

[25] Ibid., Enclosure A, para 2d(1)

[26] The issues associated with a military response to a hostile act or hostile intent are extremely complex. Even if the offending State can be identified, significant questions would arise as to the nature of the military response and appropriate targets. In the U.S., decisions about a military response would be made at the highest levels of government.

[27] Liability Convention, Article XI, para 2.

[28] I must include my appreciation to Lt Col Dean N. Reinhardt, the chief of International and Space Law at Air Force Space Command, for his assistance in the preparation of this paper. He helped me put shape to an awfully broad topic, and along the way improved my appreciation of the space domain.

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Shaping the Future with a New Space Power: Now is the Time

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While the US has been focused on the rise of China as a space power, another space power quietly emerged. The European Union (EU) took its place as a space power on 1 December 2009 when the EU Treaty of Lisbon took effect. Indeed, over the last decade, the EU has been developing significant space capabilities even though it lacked a coherent space policy, a dedicated space budget, or a space program. The EU Treaty of Lisbon addressed these deficiencies and moves the center of gravity for collective European space activities from the European Space Agency (ESA) to the EU. And the relative indifference to security space that characterized Europe's collective space efforts in the past has disappeared over the last few years. With US budgets constrained and US security space programs lagging, now is the time to partner with the EU in security space. Moreover, with deficiencies looming in two critical US security space capabilities: Earth observation and space situational awareness (SSA); now is the time to partner with the EU to narrow these gaps. Most importantly, unless we move quickly to develop a robust partnership there is some danger that European technologies and satellite architectures will evolve in ways that are incompatible with US systems—creating technological and institutional divides that deprive the US of access to important information and preclude partnership in the future. Now is the time to partner with the EU so that the US can influence EU space technology, satellite architectures, and security space institutional structures in ways which will benefit American national security for decades into the future.

And the time is now for the EU as well. In the 1960s European space policy decision-makers decided Europe must have independent space capabilities as a prerequisite for cooperation with the US as an equal partner. Europe's independent development of a space launch capability (Ariane), its independent development of telecommunication satellites, weather satellites, and now navigation satellites (Galileo) bears this out. Now the EU is on the cusp of independently developing the two security space capabilities which the US could use the most, significant Earth observation capabilities, and SSA capabilities. If the historic trend holds, that is, the European preference to first develop an independent space capability and then to begin cooperation with US, now is the time to engage the EU in discussions on cooperation in these programs.

What Changed?

The Treaty of Lisbon significantly strengthens the EU's ability to act as a global power. It provides the EU with "legal status," (meaning it now has the ability to sign international treaties); provides a mutual defense clause which significantly strengthens the EU's ability to engage in defense and military activities; and provides the EU with a more powerful foreign ministry, and a European diplomatic service—signaling that the EU will become a much more active player internationally.

The treaty is also a watershed event for the European space community. The treaty mandates the creation of an EU space program and it provides a dedicated EU budget line for space. It cements the EU's commitment to space at the highest political level, and establishes civil, commercial, and *security space* activities as important means for achieving EU political, economic, social, and security goals, both domestically and globally.[1]

Over the last 10 years, the EU has demonstrated growing confidence as a player in space—as the EU's Galileo positioning, navigation, and timing system demonstrates. Galileo proved that the EU is determined to deploy advanced dual-use space systems with significant security space capabilities, including militarily useful applications. But Galileo is just the first "flagship" dual-use EU space effort. The second is an Earth observation system called the GMES constellation and it is about to go operational. In addition, the 2007 Chinese anti-satellite weapon test spurred the EU to start the development of a third potential flagship EU space program—an autonomous EU SSA system. There is strong impetus behind all three of these efforts.

Historically, ESA led collective European space efforts. The EU was a bit player. But ESA lacks political clout in Europe, whereas EU political power mushroomed in the 1990s along with its interest in space. The EU recognized that a vigorous space program was vital to its economic and security interests. To remain relevant, ESA had to make itself pertinent to achieving EU goals. It did. Today, ESA acts as the prime contractor for the development of EU space capabilities, including space capabilities with military applications. It is said that the EU provides the "demand" for space services and ESA provides the "supply." The result has been Galileo, GMES, and the European SSA program.

More recently, the joint 2007 EU-ESA European space policy gave policy direction to EU and ESA space efforts. But two things were lacking: a dedicated space budget and a space program to give substance to that policy. The EU funded its space activities primarily through the EU transportation budgets, research budgets, even unused EU Common Agricultural Program funds, and co-funding with ESA. Now, the Lisbon Treaty will provide the EU with a dedicated budget line for space and an EU space program. The impetus the treaty gives to the EU's collective space efforts will accelerate the emergence of the EU as a major space power with the potential to be

a reliable partner for the US in the realm of security space. The Lisbon Treaty signals that now is the time for the US to explore new opportunities for security space cooperation with the EU.

Opportunity or Opportunity Missed?

In the past, many Americans, including some within the US national security establishment, have been dismissive of the EU's growing internal cohesiveness and strength as a global actor. This attitude, among other things, led the US to underestimate the EU's will to develop Galileo. Today some may believe the EU is developing only civil space systems and therefore conclude that the EU is uninterested or incapable of engaging with the US in security space cooperation. That would be the wrong conclusion. First, the US military *already* relies upon European, civil meteorological satellites for operational meteorological and environmental data in Iraq and Afghanistan.[2] Second, although the EU has developed these capabilities as civil dual-use space programs because of EU political realities and budget constraints, they have significant security space applications that the EU intends to use for defense purposes and which the US security space community should not overlook.

Why now? Because the EU is perfectly willing to develop its dual-use security space capabilities, architectures, and institutional structures without US involvement—as they proved in the Galileo case. If this happens, the risk is that incompatible technology and architectures may be developed and mismatched institutional structures and processes established that will create lasting dissonance between US and EU security space activities. Far better for the US to engage with the EU and have the chance to shape the development of the EU security space sector. The alternative is to remain on the outside, miss the opportunity for the EU to supplement US capabilities now, and even more so in the future.

As well, the need for the US to engage in a multilateral approach with Europe is to recognize some hard realities. The costs of security space activities keep rising and no one imagines that budget allocations will keep pace. In such an environment, cost sharing makes sense. Already, many US security space programs such as Space Radar, the Future Imagery Architecture, and the Transformational Satellite have foundered for lack of funds. Associated procurement debacles threaten gaps in these US security space capabilities. US SSA capabilities are also inadequate given the growing crowding of orbital space and the dawn of "contested space." As the center of gravity for Europe's collective space efforts shifts to the EU, and with emerging EU dual-use space capabilities such as GMES and SSA—now is the time for an open-minded appraisal of what the EU has to offer.

Obstacles

But will the EU want to cooperate with the US? It would be unwise of the US to conclude that the EU is so eager for greater cooperation that we can set the terms. The past record of space cooperation between Europe and the US—for example, the International Space Station and US efforts to discourage development of Galileo—have not always been positive. In addition, a growing sense of their own capability has made many in Europe skeptical about cooperation with the US. The Eisenhower Center for Space and Defense Studies has hosted two workshops with a cross section of Europeans on the prospects for cooperation. The over-riding sentiment from the European side has been skepticism, both in the good intentions of Washington and, increasingly, in the necessity (and even the advisability) of cooperating with us to achieve *their* goals in space.

We must also recognize the European perspective on security space differs from ours. European militaries are less reliant on space than the US military. And Europeans tend to see better SSA as necessary for better spaceflight safety, for regulating the space environment, and for allowing the more efficient commercial exploitation of space. They do not share our military's view of SSA as a primary means to detect and counter potential threats to space capabilities and as an enabler of space control. That means, among other things, they perceive less need for SSA data secrecy than the US does.

Nor do many Europeans share the sense of some in the US security community that China constitutes a potential emerging threat, although the 2007 Chinese antisatellite weapon test did shock European decision-makers and catalyze their sudden interest in expanding indigenous SSA capabilities. In short, Europe is more capable now, but also more skeptical of cooperation with the US, and more wary about creating an asymmetric vulnerability in space. They are also more convinced than many in the US that space—instead of being "contested" and a likely venue of future conflict—will likely continue to be characterized by the sort of grudging and sometimes tacit cooperation that has marked the domain since the dawn of the space age.

Finally, even if there is common conceptual ground for greater security space cooperation, the International Traffic in Arms Regulations (ITAR) will stand in the way. As long as ITAR exists, the breadth and depth of security space cooperation with Europe will of necessity be limited.

Still, budgetary problems exist in Europe as well as the US, our capabilities are incomparably greater, European consciousness of potential threats to space assets is growing, and the EU recognizes space as a critical component in their quest to become a global power. The basis for security space cooperation therefore exists.

Shaping the Future

The time is ripe now for the US security space community to engage the EU on GMES because GMES institutional structures are not yet set. If cooperative agreements could be made, the US might be able to influence the final shape of GMES. If we do not engage now, we will have no influence on the final structures and processes whatsoever and will likely forestall cooperation in the future. A European space official at a recent international space conference even surmised that American interest in GMES might spur the EU to make decisions on GMES institutional structures sooner rather than later. Not to thwart cooperation with the US, but in order for the EU to be in a better position to engage in discussions.

GMES is first a ground segment which will use powerful data processing tools to integrate and distribute the Earth observation data coming down from several new and already existing European civil Earth observation spacecraft. GMES information will be used by the EU for its strategic purposes and shared with EU member states. The Synthetic Aperture Radar (SAR) space systems which will contribute Earth observation information to the GMES system include ERS-2, Envisat, COSMOS-SkyMed, the Canadian RADARSAT-2, the German TerraSAR-X and TanDEM-X systems. Contributing optical systems include Envisat, the Disaster Monitoring Constellation, the German EnMAP and RapidEye, the Israeli Eros-A/-B, the French-Italian Pleides, Spain's SEOSAT-INGENIO, the French SPOT series of satellites, and the British TopSat. Contributing altimetry systems include the NASA/CNES Jason-1 and Jason-2 missions, and meteorological systems will include EUMETSAT's Meteosat Second Generation and MetOp satellite programs. GMES will also have a dedicated space segment starting in 2011 with Sentinel-1 SAR satellites, followed in coming years by Sentinel-2 optical satellites, and Sentinel-3 oceanography satellites.[3] These Earth observation systems vary widely in the type of data they collect and in image resolution—from medium resolution to less than a meter—but there is no doubt that the US could benefit from having access to GMES data. There may even be operationally responsive space implications if cooperative agreements were made for US forces to tap into these data streams in the event US space systems were attacked and disrupted. Conceptually, the EU's GMES system may have the potential to act as a reserve Earth observation capability for the US.

Much of the same may be said with regard to EU SSA initiatives. Cooperation now presents the US with the opportunity to favorably shape Europe's SSA architecture and institutional structures. If the US misses the opportunity, future cooperation could be short circuited and will definitely be much more difficult and costly. And again, a strong US interest may push the EU to make decisions on its SSA architecture and institutional structures in a more determined fashion, ultimately filling potential gaps in US SSA capabilities more rapidly than otherwise possible.

The Future is Now

The EU Lisbon Treaty signals that the EU is here to stay. Moreover, it signifies that the EU is determined to become a global power economically, politically, and in global security affairs. The treaty also demonstrates that the EU regards space—including security space—as a critical tool for achieving its goals. Over the last decade, that recognition caused the center of gravity for collective European space efforts to shift from ESA to the EU. In that time, the EU has been developing significant dual-use space capabilities and is now on the threshold of deploying them. Still, it is not too late for the US to influence the final architectures and institutional structures of the EU GMES and SSA space systems so that we may benefit from them. Engaging the EU now will insure that the opportunity for future cooperation is not foreclosed and help avert mounting deficiencies in US Earth observation capabilities and SSA. If we hesitate, we will be stuck with a go-it-alone strategy, which will become increasingly costly and increasingly ineffective. The future is in our hands. Now is the time to engage.

Notes:

1 The term "security" has defense, military, environmental, homeland, and human security connotations. In this case, it definitely includes defense and military meanings and all that implies.

2 This is done through information sharing between the US National Oceanic and Atmospheric Administration (NOAA) and European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). NOAA provides space-based meteorological and environmental data to the US military.

3 European Space Agency web site, GMES—Observing the Earth, http://www.esa.int/esaLP/LPgmes.html.

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As a foreign area officer, Colonel Gleason has experience as a political - military officer at 13th Air Force, Andersen AFB, Guam. There he served as the 13th Air Force commander's China, Indonesia, Thailand, and Malaysia desk officer with extensive official travel to those countries to arrange mil-to-mil exchanges and to liaise with the US Embassy and Defense Attaché offices in each country. He has also augmented the US Air Attaché offices in Beijing, China, and Copenhagen, Denmark.

Colonel Gleason began teaching political science at the US Air Force Academy in 2002. In 2005, he was accepted into the AFIT Civilian Institutions program and began PhD studies at the George Washington University, Washington DC. Colonel Gleason previously authored "European Space Initiatives: The Political Will for Increasing European Space Power," *Astropolitics*, volume 4, issue 1, May 2006. He also co-authored the chapter "The Civil Sector" in *Space and Defense Policy* and has presented his space policy research at conferences in Europe and in the US.

The Rise of India as a Space Power

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In January 2007, China both alarmed and frustrated the world by destroying one of its own satellites with an earth-based anti-satellite weapon.[1] However, just 19 months later, India made a much less aggressive yet equally telling statement of its own by successfully sending an indigenously produced satellite to the moon. As all eyes remain focused on China's questionable space power ambitions and on Russia's continued efforts to discourage Eastern European missile defense, India continues to quietly yet forcibly make its case as a rising space power nation. India's conversion from peaceful to military use of space applications to protect itself from regional adversaries, its projection of space power globally on the worldwide stage to attain international acclaim, and understanding what all of this means for the US requires that India's space program be carefully watched to ensure stability in the region is not disrupted.

Before exploring the current state of India's space program, the history of the program itself must be properly understood. Driven largely by the desire to harvest technology for national economic development, India's space program dates back to 1962 with the formation of the Indian National Committee for Space Research.[2] The first sounding rocket launched successfully a year later, leading to the establishment of the Indian Space Research Organization (ISRO) in 1967, and its eventual ownership of the Department of Space three years after that.[3] India launched its first satellite in 1975, and five years later launched another on its own experimental space launch vehicle from its own facility, becoming the eighth nation in the world to send a satellite into orbit above the earth. In April 1984, India sent the 138th man into space on a joint India-Soviet mission to the USSR's space station Salyut 7.[4]

Over the next several decades, India continued with a string of mostly successful remote sensing and communication satellite launches, as well as enhancing its own launch vehicle development and capabilities for both domestic and commercial use. At present, India's polar satellite launch vehicle (PSLV - first developed in 1994) and geostationary satellite launch vehicle (GSLV - first developed in 2001) allow for placing satellites in low Earth orbit (LEO) and Geosynchronous Transfer Orbit (GTO) respectively.[5] Currently, India operates two primary constellations: 11 active Indian national satellites providing civilian communication and meteorology; and 10 active Indian remote sensing satellites providing civilian imagery in a variety of resolutions and spectral bands. In the past 10 years India has also launched a handful of experimental satellites and one-time missions, the biggest of which being the recent October 2008 mission to the moon.[6]

At first glance, India's space program appears to have a foundation of non-military uses designed specifically to enhance technological development and grow the domestic economy. However, given its relationship with antagonistic neighbors, the increased exploitation of space for national security purposes by India appears to be on the rise. Utilizing intra-governmental relationships and fostering international partnerships enables India to transition a commercial space program to a militarized one. Cooperation between the ISRO and India's Defense Research and Development Organization increased significantly after the Chinese anti-satellite (ASAT) test. India's leadership acknowledges the force enabler that space systems provide, and therefore supports an increase in dual-use technology development with both military and commercial applications.[7] Additionally, India seeks to establish its own Aerospace Command, modeled after the North American Defense Command of the US and Canada. Although intended to prevent attacks from space and certainly signaling their willingness to tackle large military space projects, the development will take years to complete, making it an insignificant factor in any near-future conflict scenarios.[8] Finally, India recently entered into several military partnerships, including one with Israel jointly developing a Synthetic Aperture Radar satellite and sharing missile defense technology.[9] A 2005 agreement between India and Russia acknowledged the desire for cooperation on advanced technology, fostered a partnership on India's use of GLONASS, and signaled a transition from a supplier-client relationship to one of joint development.[10] Each new relationship breeds additional force enhancement capability to India's military establishment.

Pakistan represents the largest threat to India and the primary driver behind India's desire to pursue greater military space applications. As India seeks to develop its own indigenous missile defense system, the potential for this technology to be weaponized into a direct ascent ASAT weapon makes matters much worse.[11] Pakistan constantly seeks to match each of India's advancements, almost guaranteeing that deploying such a weapon would propel both countries into a space arms race.[12] Some even assume Pakistan would target space assets India relies on as force enablers, such as commercial imagery platforms or even global positioning system (GPS) or Galileo satellites.[13] Although an unlikely scenario given the obvious outrage and certain unforgiving response of both the US and European Union, the simple fact that such a capability could someday exist still raises eyebrows. Lastly, India's military leadership continues to publically argue for the pursuit of space-based lasers and killer satellites. Since most India-Pakistan wargaming scenarios escalate to both countries using nuclear weapons within 12 days of commencing hostilities, exacerbating Pakistani worries and further stressing an already fragile relationship with threats of weapons in space could lead to some frightening situations.[14]

Finally, China's recent thunderous space rhetoric followed by several highly publicized successes caused significant concern in India. Both countries have a history of recent conflict, to include a 1962 border skirmish in Kashmir, India's 1998 nuclear test, and China's support of Pakistan's own nuclear program. China's 2007 ASAT test fueled the already burning desire of the Indian Air Force to develop its own ASAT capability.[15] Interestingly, neither China nor India formally recognizes the near-universally accepted "open skies" doctrine conceived by Eisenhower years ago, allowing for the free passage of satellites over national territory.[16] Doctrine aside, now that India believes China can threaten its space assets, and their inability to replenish those space assets on short notice, the Indian Air Force may finally have the catalyst it needs to develop these weapons.[17] Lastly, as recent as Sept 2009, China and Pakistan partnered on a $222 million deal promoting scientific technology in Pakistan over the next several decades. Largely space centric, the agreement calls for a jointly developed replacement communication satellite and its associated ground segment, ultimately culminating with Islamabad's first indigenous satellite launch by 2011.[18] Funding the space advancement of India's primary adversary wins China no points with India's military or political establishment.

In addition to ensuring its national security regionally via space power, India also seeks to use its ascending capabilities to achieve a more global agenda. India considers the ability to send men and machines into space as a matter of national prestige, and therefore believes that the moon landing and other planned interplanetary ventures provide an ideal showcase of their scientific capabilities on a world stage. In October 2008, India joined an elite club by successfully launching an unmanned satellite to orbit the moon. Only the US, Russia, Japan, China, and the European Space Agency have accomplished the same feat, with Japan and China only reaching the moon as recently as 2007. Additionally, the mission contained a significant international flavor giving it even more exposure, with sensors integrated onto the satellite from the US, United Kingdom, Germany, Sweden, and Bulgaria.[19] Although ending prematurely in August 2009, India still claimed success since the mission met nearly all of its scientific objectives, made more than 3000 orbits around the moon, and captured nearly 70,000 images. The ISRO announced a joint collaboration with Russia for a follow-on moon mission in 2012, this time including a lunar lander and a rover.[20] A solar probe designed to study coupling between the Sun and the earth is also in development.[21] Finally, the ISRO recently kicked off preparations for a mission to Mars within the next six years using its own orbiter and launch vehicle.[22] Each of these projects allows India to flex its technological muscle in front of a global audience, further bolstering its national esteem.

India also seeks to develop a launch vehicle market to indigenously launch into both polar and geosynchronous orbits, as well as compete globally with the Russians and the European Space Agency. Marketing their space capabilities dates back to 1992 with the formation of Antrix, the commercial arm of the Department of Space designed to sell space services like GPS applications, launch options, and satellite designs to global customers.[23] Since 1999, India has successfully launched German, South Korean, Indonesian, Italian, Israeli, and Canadian satellites into orbit on their PSLV.[24] These successes prompted India to develop the GSLV Mark III, currently scheduled to launch in 2011 and intended for a commercial market.[25] The Mark III contains a Russian built third stage, which India seeks to replace with its own in the near future, reducing their dependence on Russian hardware as competition increases.[26] The additional development of a new reusable two-stage-to-orbit launch vehicle proves that India remains unafraid to tackle advanced concepts like hypersonic flight, powered cruise flight, and autonomous landing as they seek to grow their market share.[27]

Finally, India's leadership has committed their country to a trajectory culminating with their emergence as a dominant space power. In April 2007, India's then President A. P. J. Abdul Kalem outlined what he believed to be the roadmap for India's space program in the foreseeable future in a speech given at a Boston University symposium.[28] Reiterating the need for space research, President Kalem outlined the importance of space to the planet's depleting resources, citing some fantastic and mildly outlandish ideas like mining the moon and asteroids for minerals and water, manufacturing moon-based power stations, and developing reusable space planes for cheaper access to space. He ended by calling for international action and cooperation among all nations to implement these types of initiatives and ensure the peaceful use of space.[29] India's plans to send a small crew into space by 2015 represent the next big step toward this larger goal.[30] As an added benefit, such incredible visions have energized the imagination and desire in India's young scientists, allowing India the luxury of a workforce being primed to address the next series of technological challenges for an entire generation.[31]

After examining India's drive to both exploit military space power regionally and to project technological and commercial space power globally, the question remains as to what any of this means for the US. Five conclusions can be drawn from assessing where India's space program has been and where it might be headed. Each must be understood by the US as it continues its relationship with both India and its neighbors. First, the non-military, commercial-use-only days of India's space program are over. With China rattling its newly acquired (yet functionally limited) offensive space superiority saber, Pakistan advancing its own indigenous launch and satellite development capabilities, and India's own acknowledgment that space represents a significant force enhancer, the US must recognize that India will continue the transition to a dual-use space program with an increasingly military focus.

Second, as India makes this transition, the US must ensure that a space race between India, Pakistan, and China does not lead to more ASAT weapons or the worst case scenario of weapons in space. The Chinese ASAT test from 2007 cannot be undone, and the competition for each country to develop its own satellite technology and launch capabilities is a reality. However, to allow the competition and the quest for primacy to escalate to either earth-based or space-based weapons threat-

ens not only the countries of the East Asian region but also the space-based assets and ultimate war-fighting capability of the US, Russia, and European Union—something none will accept.

Third, the US must strike a balance between its relationship with India (who the US depends on as the world's largest democracy and economic partner), Pakistan (who the US depends on in the war against terror) and China (who the US depends on for commerce and financing its exponentially ballooning national debt). Some have asserted that a tertiary goal of China's recent space endeavors involves drawing India into a space arms race.[32] Additionally, Pakistan continues to wage a public relations campaign against India by openly questioning why India would use its wealth to send rockets to the moon when a majority of its overwhelmingly large population lives well below the poverty line.[33] President Barack Obama recently vowed continued cooperation with India at the first state dinner of his presidency.[34] As Pakistan activists call on the US and Russia to avoid cooperating with India on its space program, the president must negotiate the political tightrope ensuring that partnering with India on ballistic missile defense and interplanetary ventures doesn't upset our other interests in the region.[35]

Fourth, the US must recognize that India will continue to diversify its partnerships with a variety of nations. Although it seeks to develop its own ability to develop satellites, launch them, and command and control them, India also divests select portions of its programs across a variety of nations. Partnering with heavy hitters like the US and Russia on development and technology exchange, and providing services to a variety of nations like the United Kingdom, Israel, Canada, Germany, South Korea, and Belarus, provides India additional security in an increasingly globalized world. With such diverse countries both large and small invested in its space architecture, India can have the best of both worlds by retaining the ability to conduct space-based activities locally to avoid dependence if necessary, while at the same time partnering globally to retain significant international top cover.

Finally, and arguably most concerning, the US must recognize that India may soon have a space program that rivals that of the US, and even in some aspects exceeds it. As the US watched its commercial launch market evaporate, India quietly developed the ability to launch a variety of satellites to orbits ranging from LEO to GTO. Additionally, a recent National Aeronautics and Space Administration study concluded that the US return to the moon by 2020 cannot be financially achieved as currently proposed and funded.[36] As the US struggles to develop the next generation space shuttle, and grapples with whether or not to invest the expense necessary to return to the moon, India seems intent on tackling all of those questions itself in a much shorter timeframe and with more amenable government leadership. Even though India's reconnaissance capability will likely never match that of the National Reconnaissance Office, and its developing regional space-based navigation constellation can't compete with the global coverage of GPS, India stands on the threshold of significant capabilities to rival those of the US.

India sits in a part of the world dominated by animosity and competition, with any technological advancement having the potential to be misconstrued by its neighbors as a threat. As the world's largest democracy, India and the US share many political and economic objectives. As India evolves from a historically commercial space program to an increasingly militarized one, and as they continue their string of interplanetary achievements, care must be taken by the US to understand that India's actions, while not overtly aggressive, have the potential to introduce additional hostility into an already sensitive region.

Notes:

[1] BBC News, "China Confirms Satellite Downed." 23 January 2007, http://news.bbc.co.uk/2/hi/asia-pacific/6289519.stm.

[2] Spacetoday.org, "The History of India in Space," 2005, http://www.spacetoday.org/India/IndiaSpaceHistory.html

[3] AerospaceGuide.net, "India in Space—Indian Space Program." 2009, http://www.aerospaceguide.net/worldspace/india_in_space.html

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[6] India Space Research Organization, 2009, www.isro.org.

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Maj Jeffrey W. Bogar (BS, Industrial Engineering, Texas A&M University, College Station, Texas; MBA, Webster University, El Segundo, California) is currently a student at Air Command and Staff College at Maxwell AFB, Alabama.

In October 2007, Maj Bogar was the director of operations at the National Reconnaissance Office (NRO), Vandenberg AFB, California, as well as the second in command of a squadron of over 300 members. In Aug 2005, Maj Bogar was assigned to the Advanced Plans Division of the Office of Space Launch at NRO HQ in Chantilly, Virginia, where he was responsible for providing launch service support to compartmentalized programs. Additionally, he was detailed to the Missile Defense Agency as the space tracking and surveillance system advanced technology risk reduction (STSS ATRR) launch segment manager to assist in launching STSS ATRR satellites from Vandenberg AFB.

In previous assignments, Maj Bogar has served at the Aerospace Data Facility at Buckley AFB, Colorado in both acquisition and operations positions; and was assigned to the Launch Programs Directorate at the Space and Missile Systems Center, Los Angeles AFB, California working for the Titan Program Office.

Mission Assurance Capability for Access to Space

Mr. Jean-Yves Le Gall
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At a time when assured access to space is increasingly important for the warfighters' ability to talk, see, and listen, many countries have come to rely on a highly active launch site in South America for rapid, secure, and flexible delivery of national security payloads into orbit.

This facility is the Guiana Space Center—also known as the Spaceport—which is home to the family of launch vehicles operated by Arianespace. On Christmas Eve 1979, the successful flight of the Ariane 1 launch vehicle from the Spaceport ushered in a new era in space transportation. Now celebrating its 30th year of continuous service, it is the launch base for the Ariane 5, whose most recent mission orbited the Helios 2B second-generation military reconnaissance satellite for France and European partners, all of which are members of North Atlantic Treaty Organization (NATO).

The Spaceport was born out of the necessity for assured access to space, having been established by European countries convinced that a strategically-located facility was vital for its long-term plan to develop a viable space program.

Since that first liftoff in 1979, Ariane vehicles have flown 193 missions as of 1 January 2010, lofting 277 payloads. This encompasses more than 50 percent of all commercial satellites placed into orbit for the world, along with 33 national security-related payloads for five NATO nations that include reconnaissance satellites, secure telecommunications platforms, and demonstrators for a space-based ballistic missile early warning system.

Situated in French Guiana, the Spaceport's location allows for launches into all useful orbits, from northward launches to -10.5 degree (deg.) through eastward missions to +93.5 deg. Its near-equatorial position at 5.3 deg. North latitude makes it ideally-situated for missions into geostationary orbit—as launching from near the equator reduces the energy required for orbit plane change maneuvers, saving fuel, and enabling an increased operational lifetime for satellite payloads.

In addition, French Guiana is protected from hurricanes and earthquakes, giving it unique advantages as a highly operational space base.

Arianespace's current launcher, the heavy-lift Ariane 5, is able to fly seven missions per year from the Spaceport, and is produced in two standardized versions that ensure high reliability and availability through production repeatability.

The Ariane 5 ECA version can place more than 20,700 pounds (lb.) (9,100 kilograms [kg.]) into geostationary transfer orbit, enabling it to efficiently carry two medium-sized telecommunications satellites on a single launch, or accommodate the largest, most powerful relay platforms as solo payloads.

The Ariane 5 ES version is the answer to low Earth orbit missions, including polar-orbiting reconnaissance satellites, the deployment of satellite constellations, and servicing the International Space Station (ISS). The flawless ATV-1 mission—named after science fiction writer Jules Verne and launched on Ariane 5 in 2008—lofted over 20 metric tons, bringing scientific experiments, food, water, and reboost/debris avoidance capabilities to the ISS.

Arianespace utilizes a pair of operational launch tables for Ariane 5, which enables the company to prepare two missions in parallel for sustained mission rates, while also giving it a demonstrated surge capability of up to nine flights in a 12-month period. With a total of 49 launches performed to date—including 35 back-to-back successes during the past seven years—Ariane 5 has earned its reputation as the workhorse vehicle for the commercial launch services sector.

Ariane 5 has demonstrated its ability to provide rapid-reaction lift capability that meets operators' critical mission timing requirements. An excellent example was Arianespace's launch of Hughes Network Systems' SPACEWAY 3—a cutting-edge satellite for the delivery of broadband services to government, enterprise, and consumer users throughout North America. When another supplier failed to provide the promised launch services, Hughes Network Systems turned to Arianespace, which successfully orbited the 13,390-lb. spacecraft only seven months after contract signature.

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Figure 1. With its successful March 2008 mission with Europe's Automated Transfer Vehicle, Arianespace's heavy-lift Ariane 5—and its Spaceport launch site—joined the limited "club" that supports operations for the International Space Station.

30 Years of Success

During its 30 years of operation, the Spaceport has continuously evolved and is one of the most modern launch facilities in service today. The Spaceport is operated by the Centre National d'Etudes Spatiales [CNES], the French national space agency, and the French government provides the same protection level as its

nuclear forces, with the launch base protected by the country's Army, Navy, Air Force, Gendarmerie, and the famous French Foreign Legion.

In addition to its launch zones, the Spaceport also includes state-of-the-art payload preparation facilities. The totally secure and highly versatile S5 facility has three primary preparation halls that allow multiple payloads to be prepared in separate, but parallel campaigns using the center's more than 15,069 square feet of clean room area. The S5 can simultaneously process up to six spacecraft with tailored security plans meeting the strictest national security requirements. A few miles away, the S3 satellite preparation center enables a satellite's full preparation process—including checkout, fueling and final pre-launch validation—to be performed under one roof in clean room conditions.

Known mostly for its ability to launch commercial telecommunications payloads, the Ariane 5 has also played a role in augmenting communications and test sensors for the US government with the deployment of "hosted payloads" on launches from the Spaceport. The "hosted payload" concept allows a government customer to attach its own payload to a commercial satellite, providing a shared platform for augmented communications (X, UHF, Ka-Band) or navigation capabilities (Global Positioning System or Wide Area Augmentation System); demonstrating new sensors and observation technologies (infrared and optical); and for increasing space situational awareness (monitoring, detection, and avoidance).

The benefits of such an arrangement are trifold: time and money saved, as well as risk reduction. With new bandwidth needs and requirements increasing at a rate that outstrips normal procurement cycles, hosted payloads could provide new bandwidth and new technologies as needs arise. An example of such a mission was the hybrid commercial/government Galaxy 15 spacecraft orbited by Arianespace in 2005. In addition to its complement of C-band commercial transponders, Galaxy 15 carried an L-band navigation payload for in-flight aircraft as part of the Federal Aviation Administration's Geostationary Communications and Control Segment (GCCS). This successful Ariane 5 launch with Galaxy 15 was performed in October 2005 on a flight that also carried the Syracuse 3A secure telecommunications platform for France's Ministry of Defense—underscoring this launch vehicle's capability to match up mixed payloads on its trademark dual-satellite missions.

Arianespace is already on track to perform several hosted payload missions that will help meet some of the Department of Defense's crucial satellite capacity needs. Within the next two years, Arianespace will launch the Commercially Hosted Infrared Payload (CHIRP) as part of an Orbital Sciences-built satellite for SES AMERICOM Government Services. The CHIRP Flight Development program is designed to "reduce risks in the development of wide field-of-view starring infrared sensors" for the US Air Force.

Expanding Family and Launch Opportunities

The Arianespace launcher family will expand in 2010 with the addition of two more vehicles: the medium-lift Soyuz and the lightweight Vega, which will operate along with Ariane 5 from separate, dedicated launch sites at the Spaceport.

Soyuz missions from French Guiana will mark a new chapter in the history of this venerable launcher, which opened the conquest of space in 1957. Since then, Soyuz has been in continuous production, demonstrating unmatched reliability with more than 1,750 missions performed to date. The modernized version of Soyuz to be operated by Arianespace is capable of carrying telecommunications satellites weighting up to 6,835 lbs. (3,060 kg.) to geostationary transfer orbit. Soyuz also is perfectly matched for missions with observation satellites and scientific payloads.

The lightweight Vega has been conceived specifically for small satellites, providing efficient access to low Earth orbits and Sun-synchronous orbits. Developed specifically for Arianespace, Vega's target payload lift capability is 3,300 lbs. on missions to a 435-mile circular orbit.

Ariane 5's manifest, which runs the gamut of scientific, commercial, and governmental payloads, along with Soyuz and Vega, will continue to demonstrate Arianespace's unrivalled ability to place any payload to any orbit at any time for any national security need, from Europe's Spaceport in French Guiana.

We look forward to our next 30 years of service where government customers can leverage the significant investments made by Europe in the Spaceport's state-of-the-art payload processing and launch facilities, providing critical mission assurance capability.

Jean-Yves Le Gall is the chairman and chief executive officer of Arianespace, the world's leading launch service and solutions company. His main mission is to define the company's commercial strategy, and to develop and maintain a close relationship with its international clientele. As part of his job, he represents Arianespace in relations with European governments, space agencies, industrial partners, and shareholders in the company. Mr. Le Gall is also chairman and chief executive officer of Starsem, the company's European-Russian subsidiary in charge of operating and marketing the Soyuz launch vehicle. Mr. Le Gall has devoted his entire career to the European space program. He has held a number of management positions concerning both programs and strategy with several organizations, including the French Ministry of Industry, Novespace, French space agency CNES, Starsem and Arianespace, which he joined in 2001.

He is a member of the International Academy of Astronautics and he received the Astronautics Prize from the French Association of Aeronautics and Astronautics in 2001. He was recognized by the magazine *Via Satellite* as its 2005 Satellite Executive of the Year, and received the Lifetime Achievement Award in 2007 from the Asia-Pacific Satellite Communications Council. He is now chairman of the Industry Relations Committee of the International Astronautical Federation and co-chairman of the European Union-Japan Business Round Table. Le Gall holds the rank of Knight in both the Legion of Honor and the National Order of Merit. He has been awarded "Ordre de l'Amitié" from the Russian Federation.

Industry Perspective

Commercial Operators Partnering with the Military to Meet Global Bandwidth Demands

Mr. David McGlade
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In his memoirs following World War II, Army General Omar Bradley observed that "A piece of paper makes you an officer; a radio makes you a commander." Bradley could never have imagined that, one day, communication satellites would take the radio to space, and that pilots in the US would fly unmanned aircraft into hostile territory half-way around the globe through a geostationary satellite link. The development of global positioning technology, the almost-instant access to satellite imagery, and the advent of broadband satellite connections to mobile flying platforms have forever changed how the men and women of the US military turn strategy into action in both war and peace. Some of the best minds in the military are today engaged in planning how space systems can further transform the task of the commander and the warfighter.

The armed force's heavy dependence on space-based networks has created two fundamental challenges for military leaders. First, they must continuously push the envelope of satellite technology to meet the explosive demand for global communications capacity. Second, they must continue to serve the legacy networks and terminals deployed around the world and in daily use by the men and women of the military. Maintaining the balance between today's globally deployed equipment and tomorrow's technology requires complex planning and significant resources.

Commercial satellite companies have historically played a vital role in helping military and intelligence leaders overcome the hurdles inherent in meeting these twin challenges. Because of the size of their global constellations (Intelsat flies a fleet of 51 satellites, its rival Stirling Energy Systems, Inc. [SES] operates approximately 45 spacecraft) the commercial operators have the flexibility to respond to military needs by designing new systems and networks, moving existing satellites to new locations, or shifting commercial customers from one satellite to another. Using these techniques, satellite operators can find additional capacity for military communications, or fill a bandwidth "gap" between the demise of one military satellite constellation and the launch of another. The international role of commercial providers has become even more critical in the past decade. Broad engagements in Iraq and Afghanistan have consumed the lion's share of military bandwidth and nearly all of the available commercial satellite capacity in the Indian Ocean Region.

Satellite bandwidth is the "fuel" that powers today's military communications. The deployment of each new unmanned aerial vehicle (UAV) requires a significant amount of bandwidth that must either be acquired on an existing satellite or on a new satellite launched for that purpose. As consumer demand for multi-channel television programming has driven an exponential increase in demand for satellite capacity, each new UAV delivered will, by definition, increase the military's bandwidth needs. Put simply, the number of information nodes used in the battlespace that can send and receive satellite signals has outpaced the supply of new satellite systems placed in orbit to process those signals.

This disparity in supply and demand has happened for two reasons. One is that military planners, focused on the long-term needs of the military, are intrinsically geared towards "next generation," government-owned-and-operated networks. Government procurement officials historically have ordered up global constellations of spacecraft with multiple features and advantages for as many users as possible.

Ambitious plans in any arena almost always encounter setbacks and delays, and creating a global constellation of state-of-the-art satellites is certainly ambitious. Recent examples of this fact include the cancelled Transformational Communications Satellite (TSAT) program and the now-delayed Mobile User Objective System (MUOS) program. The administration decided to cancel TSAT, its flagship program to provide global net-centric communications, as a result of the programs technological risk, high cost, and development delays. According to recent congressional testimony, MUOS, which was supposed to provide continuity for the nearly defunct ultrahigh frequency follow-on (UFO) satellites, is now about two years behind its planned schedule. MUOS, when implemented, will provide cell-phone-like, narrow-band services to military users anywhere on Earth over the ultrahigh frequency (UHF) radio band. This system highlights the important challenges facing satellite planners when they attempt to transition from legacy to next-generation hardware.

A second and perhaps more critical reason bandwidth supply often lags demand relates to the way the military buys com-

Put simply, the number of information nodes used in the battlespace that can send and receive satellite signals has outpaced the supply of new satellite systems placed in orbit to process those signals.

mercial capacity. Commercial satellite customers, recognizing the strategic need for long-term access to space capacity, are accustomed to signing long-term (up to 15-year) contracts with satellite operators, often pre-committing to capacity prior to a satellite's launch. Satellite operators then implement fleet plans to meet the long term needs of their customers. These successful customer-operator partnerships are the foundation of the commercial satellite industry.

With the partial exception of the US Navy, the services are not geared to contract for long-term commercial satellite capacity. Instead, they acquire it on a year-to-year basis with supplemental funds appropriated by Congress. When a new commercial satellite is launched, it is not unusual for the majority of capacity to already be contracted. In these cases, the military often gets only what little capacity remains in the commercial satellite constellation. Buying the excess capacity on a satellite may prove sufficient for military needs in peacetime. However, the ever-lengthening engagements in Iraq and Afghanistan have shown conclusively that the military needs to partner with the commercial space industry to meet bandwidth needs in wartime.

Figure 1. Predator Unmanned Aerial Vehicle.

The surge in bandwidth demand for UAV operations in Afghanistan is one important example. The technology to fly and control UAVs was developed under a government research program without much long-term insight into how much satellite bandwidth the aircraft would require. The early Global Hawk and Predator UAVs designed for intelligence, surveillance, and reconnaissance (ISR) had relatively simple sensors for imaging small areas.

That basic function has evolved into craft equipped with precision targeting and missile launching capability and sophisticated sensors transmitting real-time feeds of large swaths of ground—all controlled by a mission team thousands of miles away. A Predator currently has a data-return capability of 3.2 megabits per second (Mbps), but that is expected to increase to 45 Mbps within five years because of the increase in sensor variety and capability. In the same period, a Global Hawk's data-return rate is expected to grow from 50 Mbps to 274 Mbps. Today, there is no satellite flying—either commercial or military—that could handle the Global Hawk's projected bandwidth requirements.

Existing government satellite fleets have proved incapable of providing all the bandwidth needed to support the expanding data requirements of UAVs in Iraq and Afghanistan. When US operations in Iraq and Afghanistan started in 2001, the military turned to the commercial industry for Ku-band capacity. At the time, the commercial satellite industry had surplus capacity and was able to meet this new requirement. Today, more than 90 percent of the satellite bandwidth used in the region by the military is supplied by commercial satellite companies. The Department of Defense's (DoD) demand for commercial services, combined with the robust growth of the economies in Africa and the Middle East, have resulted in frequent capacity shortages in the Indian Ocean region.

The availability of commercial Ku band for UAV traffic is not the only bandwidth challenge facing the US military today. The provision of UHF capacity to the US military provides another powerful example of how commercial firms can be called upon to provide bandwidth in response to military shortfalls. The commercial Marisat satellites launched in the 1970s filled the UHF-capacity gap until the Navy's Fleet Satellite Communications System (FLTSATCOM) went online in 1981. Even then, Marisat continued to provide service to military forces alongside the FLTSATCOM constellation. A decade later, the Intelsat constellation of Leasat satellites provided UHF capacity in the period between FLTSATCOM's end of life and the first UHF UFO system launch in 1993.

The UFO satellites are now nearing the end of their useful life. The constellation designed to replace them is the now-delayed MUOS system. Vice Admiral Harry Harris, the deputy chief of naval operations for communications Networks, told a Senate subcommittee this spring that by May 2010, the UFO constellation is expected to reach "an unacceptable level of availability." Harris also said that despite allocating 80 percent of the government's narrowband UHF capacity to the Iraq and Afghanistan theaters, military UHF networks have only been able to satisfy about 20 percent of user tactical demand. With the UFO constellation dying and MUOS not expected to be operational until 2012, there will be another "gap" in military capacity that, unfortunately, commercial operators will not be able to fill because there is very little commercial UHF bandwidth available.

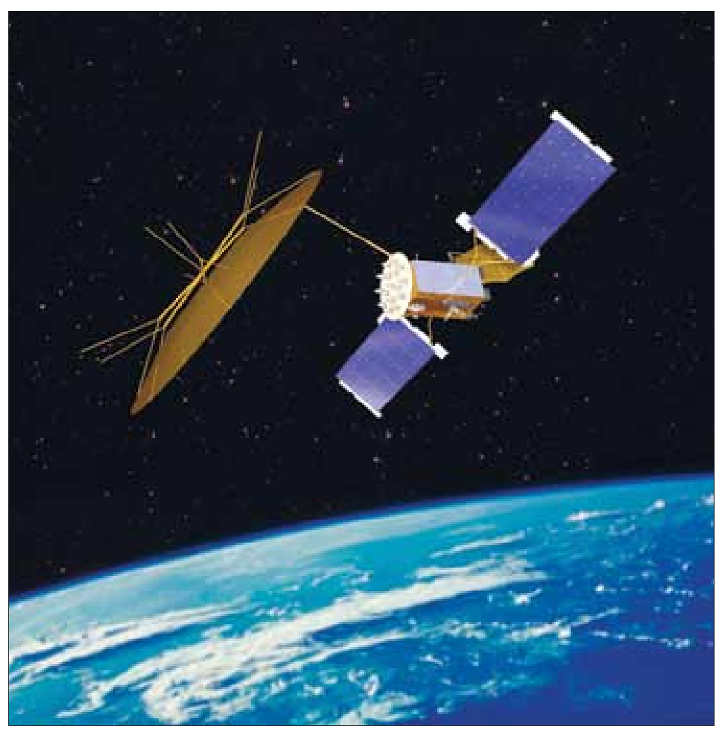

Figure 2. Mobile User Objective System Information (MUOS).

Figure 3. Intelsat 22 Satellite.

does not take into consideration what may be a rapid increase in demand for the MUOS system once soldiers, sailors, and marines realize how easy it is to use.

With the existing UFO constellation approaching end of life and the MUOS system being short of new terminals, there could be a 10-year gap that the commercial industry could fill by launching new UHF capacity for the legacy terminals. This could be done most easily and cost effectively by adding a UHF hosted payload to a number of commercial satellites. This is exactly the approach taken by the Australian Defence Force (ADF) in contracting with Intelsat earlier this year for a UHF hosted payload for military communications in the Indian Ocean region. The Intelsat 22 satellite will be launched in 2012, just three years after contract signing.

Because the UHF bandwidth is reserved for government use, commercial companies only build and launch new UHF capacity with government sponsorship in hand. The earlier Marisat and Leasat constellations came out of such arrangements. However, since the launch of the final Leasat spacecraft in 1990, no commercial company has been called upon by the US military to provide additional UHF bandwidth. There is some capacity available on satellites operated by America's European allies, but not nearly enough to meet the expected capacity shortage in the next few years.

Even with MUOS on the way, the commercial industry may be able to assist with a continuing UHF shortage. The reason is that any fundamental change in satellite technology orphans existing terminals when users transition to all new ground equipment. This is expensive and disruptive, especially in the case of UHF, because many terminals are embedded in vehicles, aircraft and ships and cannot be easily changed out. As a result, current plans assume that the first few MUOS satellites will carry two communications payloads: the primary payload to send and receive the MUOS waveform that requires new ground terminals, and a secondary one that can still communicate with the existing, older UHF ground terminals.

The US military currently has about 40,000 legacy UHF terminals in use around the globe. When the first MUOS satellite becomes operational in 2012, only about 4,000 new MUOS terminals are expected to have been built, according to an analysis by the US Government Accountability Office (GAO). The GAO estimated that the full complement of 40,000 replacement MUOS terminals will not be ready until around 2021, when the first satellite reaches the half-way point in its expected service life. Moreover, estimating how many terminals will be needed

Hosted payloads also offer the potential for significant costs savings. Following the ADF purchase of a hosted UHF payload, the Honorable Joel Fitzgibbon, Australian minister of defense, stated that this program had saved the Australian taxpayer over $150 million when compared with launching a dedicated satellite.

The same steps could be taken to get bandwidth capacity into space to meet the operational requirements of UAVs. Although US operations in Afghanistan may wind down in the next couple of years, the US military has grown so accustomed to the ISR benefits of UAV operations that domestic and global demand for the vehicles and the associated satellite bandwidth will likely continue to grow. With so many regions of the world in turmoil and budget dollars tight, UAVs provide an ideal method of gathering ISR data before committing troops.

A number of top military officials speaking in public forums recently have made clear that they view the commercial satellite industry as a trusted partner and that the government needs to find a better way to work with the industry in both ordering and procuring urgently-needed satellite bandwidth. These officials have admitted that continued delays and cost overruns in military satellite projects have impeded our nation's ability to deliver the next generation of space capability, and that the frailty of existing systems directly impacts military operations every day.

Such candidness is refreshing, and reflects a new awareness that could help resolve current problems with how the military contracts for its commercial capacity. The cancellation this past year of the Air Force's TSAT constellation, after an

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The lives of our warfighters depend upon communications in the field. The global bandwidth crisis is real, and the commercial satellite industry stands ready to become a true partner with the military in providing the satellite capacity to solve this problem.

investment of nearly $3 billion, displays the harsh reality of budgetary concerns that will likely cloud the next generation of military spending programs. The military has already shown a willingness to sign long-term commercial contracts for the basic mapping mission of the US government and the gathering of medium-resolution remote-sensing data. The same approach could be applied to the full range of military needs. However, it is most urgent in dealing with the shortage of UHF bandwidth worldwide and ISR capacity for UAV operations in specific parts of the globe. Based on the model established in the imagery industry, long-term stable contracts could be used to ensure continuity for legacy UHF services or for dedicated Ku or Ka band ISR capacity.

With its fleet of 51 satellites, Intelsat normally has a number of replacement spacecraft in some stage of procurement. Today, for example, Intelsat has nine satellite projects in various stages of development. Hosted payloads offer the quickest and most cost-effective access to space for a military customer. A military payload could be hosted on a number of spacecraft that will be going into orbit over any of several vital regions in the next few years. Such payloads could be operated for the military by the commercial provider under a lease arrangement, or could be owned and operated by the government much as military satellites are.

Fifty years have passed since the first communications satellites began to make the world smaller by enabling global communications. In that time, we have seen a slow evolution from a tradition in which only government satellites served our military forces, to one today in which commercial satellites provide more than 90 percent of C- and Ku-band satellite bandwidth to the military in the most active theaters of operation. Commercial firms should now be called upon to provide vital UHF capacity as well. By most measures, the commercial satellite industry has proven through decades of service to a range of customers that it can deliver assets to space more quickly and at a lower price than any comparable government-sponsored effort.

The lives of our warfighters depend upon communications in the field. The global bandwidth crisis is real, and the commercial satellite industry stands ready to become a true partner with the military in providing the satellite capacity to solve this problem. But partnership requires action and a defined set of roles and responsibilities. This should not be difficult. One way to carve out the role for commercial partners is to place consistent, recurring requirements on commercial systems and surge on military systems. Another option is to let the commercial industry build and launch capacity to serve legacy requirements while military will focus on more complex and enhanced features. Yet another option would be to divide requirements by security levels and utilize both systems appropriately. This balanced approach would provide improved diversity and redundancy as well.

There are many logical partnership arrangements. We should move quickly toward a solution that is prudent in this budget environment yet still maintains our space superiority and gives our warfighters the advantage they deserve.

Mr. David McGlade (BA, Communications, Rutgers University, New Jersey) is the Chief Executive Officer of Intelsat, Ltd., he heads the world's leading provider of fixed satellite services (FSS), with operations that include a global network of commercial communications satellites and terrestrial infrastructure serving over 200 countries and territories. Mr. McGlade is a 25-year telecommunications and media industry veteran with experience in cable TV, broadband and wireless. At Intelsat, Mr. McGlade is focused on continuously improving operations and on creating new revenue growth through enhanced communications service offerings for Intelsat's customers in the media, network services and government/military sectors.

During his tenure at Intelsat, Mr. McGlade led the company's 2006 acquisition of PanAmSat, a $6.4 billion transaction, which created the industry's largest satellite operator, with leading positions in each of the customer sectors served by the company. Revenue and revenue backlog for the year ended 31 December 2007 was approximately $2.2 billion and $8.2 billion respectively. This acquisition, and the subsequent highly successful integration, resulted in an attractive valuation expansion, reflected in the sale of Intelsat in February 2008 to a consortium of investors led by BC Partners. The acquisition transaction valued Intelsat at an enterprise value of $16.4 billion.

Mr. McGlade joined Intelsat in April 2005, following the company's acquisition by a group of private equity firms, collectively named Intelsat Holdings. Prior to joining Intelsat, he served as chief executive officer of O2 UK (previously BT Cellnet) since October 2000. Mr. McGlade has extensive experience bringing new technologies and converged services to businesses and other customers. As President, West Region, Sprint PCS, he launched the first CDMA network outside of Asia.

Spacefarers and Satellite Operators: A Proliferation of Countries, Organizations, and Companies, 1957–2009

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In the beginning, the US and the Soviet Union competed to put satellites in Earth orbit, landed humans on the moon, and launched robotic spacecraft on interplanetary voyages. Only the most militarily and economically powerful nations seemed able to muster the resources needed to undertake and sustain space operations. Superpower competition largely obscured fledgling international space enterprises. Over time, however, more countries with fewer resources managed to join the ranks of satellite owners and operators. Initially, many purchased spacecraft manufactured outside their borders and relied on the few nations or organizations with launch capability to send them into orbit. Some of those lesser powers eventually managed to build their own satellites or form partnerships to advance their presence in outer space. Consequently, a half century after the dawn of the space age, slightly more than 50 countries claim a presence in space. Many people, rightly or wrongly, now view "spacefaring" as relatively commonplace.

Although purists might confine their list of spacefaring nations to those that have built, launched, and returned crewed spaceflight missions, a somewhat broader definition includes any nation or organization that has successfully launched a satellite into Earth orbit. The latter criterion, as of November 2009, includes less than a dozen nations, whereas the narrower definition covers only three—Soviet Union/Russia (1961), US (1961), and China (2003). An even more inclusive definition would make room for nations, regardless of launch capability, that own and operate at least one satellite in Earth orbit. In the loosest sense, one could expand the list of spacefaring entities considerably by including any that have launched a suborbital payload. Some historians might begin that list with Germany, which successfully launched an *Aggregat-4* rocket in October 1942; they might point to South Korea's failed orbital attempt in 2009 as the most recent addition. Others, almost certainly, would include on the suborbital list US citizens who privately achieved spacefaring status—CSXT's *Go Fast* amateur rocket (2004) and Scaled Composite's piloted *SpaceShipOne* (2004). In 2008, of course, SpaceX's *Falcon 1* rocket became the world's first privately funded launcher to send a payload (mass simulator dubbed *RatSat*) into Earth orbit and, in 2009, the first to successfully launch an operational satellite—Malaysia's *RazakSat*.

Since October 1957, spaceflight has become essential to the political, social, economic, and national security interests of many nations. Indeed, if one defines "international space" as cooperation or collaboration among two or more nations or organizations possessing capabilities related directly to spaceflight, the history of the last 50 years is replete with examples. From the United Kingdom and the US joining forces to build and launch the world's first international satellite—*Ariel 1*—in 1962, to the European Space Agency and International Space Station partnerships of the present, countries around the globe have combined their capital, skills, and technologies to achieve together what one or another could not do alone. Furthermore, at the corporate level in 2002, US rocket manufacturer Lockheed Martin began using RD-180 liquid-propellant engines manufactured by NPO Energomash in Russia to power the Atlas V evolved expendable launch vehicle. From the National Space Society's annual International Space Development Conference, which originated in 1982 under the auspices of the L5 Society, to the International Space University, founded in 1987, signs and signals of global collaboration to promote spaceflight have increased. Creation of the Pacific International Space Center for Exploration Systems in 2007 is just one example. Most recently, *Space News* reports that French defense officials are seeking partners among other European governments to invest in military space projects, and US President Barack Obama likely will place high emphasis on international cooperation when he announces a new national space strategy in mid-2011.

As governments, industries, and universities increasingly pool their resources to reach outer space and operate in it, history might be instructive. The table on the following page provides a chronological perspective on the global proliferation of nations with some degree of operating capability in Earth orbit. Before 1970, only four nations could legitimately claim a space-launch capability, and only eight had orbiting satellites; by 2000, the number with space-launch capability totaled 10, and 38 possessed Earth-orbiting satellites. Some, like Turkey in 1994, originally had purchased a satellite from a foreign manufacturer and subsequently, like Turkey in 2009, managed to build their own satellite. At least ten countries, including Turkey, were in the process of developing an indigenous small-launcher capability in 2009.

Perusal of the companies operating commercial satellites provides another way to gauge international space activity over time. The US Communications Satellite Act of 1962 created COMSAT Corporation, which helped form the International Telecommunications Satellite Consortium (INTELSAT) in 1964. Today, INTELSAT has more than 140 member countries and signatories, and it is only one of at least seven international companies providing satellite communications. Even though the vast majority of satellite communications companies claim a particular country as home, their coverage extends regionally or globally. For example, Globalstar, Inc., based in the US, offers low-cost voice and data services in more than 120 countries.

Countries Operating in Space			
Country	**First Launch**	**First Satellite**	**Payloads in Orbit**
Soviet Union/Russia	1957	1957	1398
United States	1958	1958	1042
United Kingdom	1971	1962	25
Canada		1962	25
Italy		1964	14
France	1965	1965	44
Australia	1967	1967	11
Germany		1969	27
Japan	1970	1970	123
China	1970	1970	83
Poland		1973	?
Netherlands		1974	5
Spain		1974	9
India	1980	1975	34
Indonesia		1976	10
Czechoslovakia		1978	5
Bulgaria		1981	1
Brazil		1985	11
Mexico		1985	7
Sweden		1986	11
Israel	1988	1988	7
Luxembourg		1988	15
Argentina		1990	10
Pakistan		1990	5
South Korea		1992	10
Portugal		1993	1
Thailand		1993	6
Turkey		1994	5
Ukraine	1999	1995	6
Chile		1995	1
Malaysia		1996	4
Norway		1997	3
Philippines		1997	2
Egypt		1998	3
Singapore		1998	1
Taiwan		1999	9
Denmark		1999	4
South Africa		1999	1
Saudi Arabia		2000	12
United Arab Emirates		2000	3
Morocco		2001	1
Algeria		2002	1
Greece		2003	2
Nigeria		2003	2
Iran	2009	2005	4
Kazakhstan		2006	1
Belarus		2006	1
Colombia		2007	1
Vietnam		2008	1
Venezuela		2008	1
Switzerland		2009	1

Source: Wikipedia *Note:* Since not checked against other sources, payload numbers only provide perspective on the relative strength of national space activities.

Iridium LLC, headquartered in Bethesda, Maryland, boasts that it is "the world's only truly global mobile satellite communications company." Nearly two dozen other North American companies extend space-based communication services of one kind or another beyond national boundaries; approximately 30 companies in nearly 20 nations across Asia and Oceania, and another 20 companies across more than 10 European countries, provide similar regional services.

As technology in the 1990s enabled the manufacture of cheaper, highly sophisticated, small satellites for civil or military communications, remote sensing, or scientific research, poorer nations found they could join the ranks of satellite owners. Surrey Satellite Technology Ltd. (SSTL), for example, was founded in 1985. It manufactured and sold small satellites to nations like South Korea (1992), Portugal (1993), Algeria (2002), and Nigeria (2003). Since 2005, SSTL has been fully owned by EADS Astrium, an international company with more than 10,000 employees in France, Germany, the United Kingdom, Spain, and the Netherlands. In October 2009, EADS Astrium signed a major contract with Kazakhstan Gharysh Sapary, the national company responsible for development of that nation's space program, to provide two Earth observation satellites and to undertake a joint venture for construction and management of an assembly, integration, and test facility in Astana, the capital of Kazakhstan. This represents the merest sampling of how globally intertwined corporate and national space activities have become.

By 2009, citizens of spacefaring and non-spacefaring nations alike, even inhabitants of the remotest places on Earth, could benefit from international space activities. As but one example, the Navstar Global Positioning System (GPS), fully operational since 1995, supplied precise positioning, navigation, and timing information to anyone with receiver equipment manufactured in several different countries. GPS was recognized as a global utility by 2000. Not long thereafter, manufacturers began designing Global Navigation Satellite System receivers that integrated signals from Russia's GLONASS and Europe's Galileo with those from GPS. Whether one viewed them from the perspective of the space, ground, or user segments, international space ties were, most assuredly, becoming ever more numerous and more complex.

Dr. Rick W. Sturdevant (BA, History, University of Northern Iowa; MA, History, University of Northern Iowa; PhD, University of California, Santa Barbara) is deputy command historian, Headquarters Air Force Space Command (HQ AFSPC), Peterson AFB, Colorado. He joined the Air Force History and Museums Program in April 1984 as chief historian, Airlift Information Systems Division, Scott AFB, Illinois, and moved one year later to the Chidlaw Building near downtown Colorado Springs as chief historian, Space Communications Division (SPCD). When SPCD was inactivated in 1991, he moved to the HQ AFSPC history office and became deputy command historian in 1999.

An acknowledged expert in the field of military space history, Dr. Sturdevant appears frequently as a guest lecturer on space history topics and is author or co-author of chapters or essays in *Beyond the Ionosphere: Fifty Years of Satellite Communication* (1997); *Organizing for the Use of Space: Historical Perspectives on a Persistent Issue* (1995); *Golden Legacy, Boundless Future: Essays on the United States Air Force and the Rise of Aerospace Power* (2000); *Air Warfare: An International Encyclopedia* (2002); *To Reach the High Frontier: A History of US Launch Vehicles* (2002); *The Limitless Sky: Air Force Science and Technology Contributions to the Nation* (2004); *Encyclopedia of 20th-Century Technology* (2005); *Societal Impact of Space Flight* (2007); and *Harnessing the Heavens: National Defense through Space* (2008). His articles or book reviews have appeared in such journals as *Space Times*, *Journal of the British Interplanetary Society*, *Air & Space/Smithsonian*, *Quest: The History of Spaceflight Quarterly*, *Air Power History*, *High Frontier: The Journal for Space & Missile Professionals*, and *Journal of the West*. He sits on the editorial board of *Quest* and on the staff of *High Frontier*.

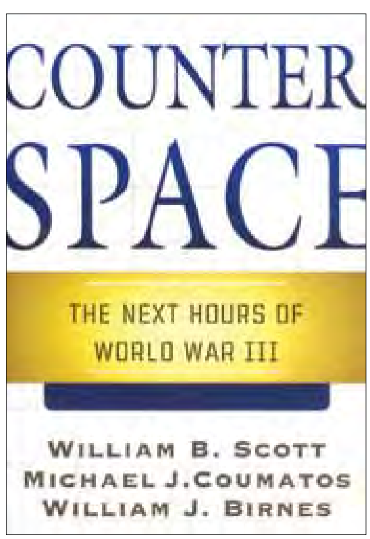
Counterspace: The Next Hours of World War III

Counterspace: The Next Hours of World War III. By William B. Scott, Michael J. Coumatos, and William J. Birnes. New York: Forge Books, 2009. Pp. 352. $25.99 Hardback ISBN: 978-0-7653-2232-6

Fast-forward one year beyond the events covered in *Space Wars: The First Six Hours of World War III* (reviewed in volume 4, number 1 of *High Frontier*) and, in March 2011, the US faces even more serious challenges to its national security. *In Counterspace: The Next Hours of World War III,* their second book in a fictional series about space warfare, authors William Scott, Michael Coumatos, and William Birnes continue the saga they began in *Space Wars*. Their cast of rogues expands in this sequel from terrorists, Iran, North Korea, and a Chinese faction to include Venezuela and an American traitor who happens to be the president's national security advisor. An almost inexplicable North Korean high-altitude nuclear blast further weakens US space posture, already severely degraded by the 2010 attacks. This opens a Pandora's box full of escalatory actions and reactions that bring China and the US to the brink of thermonuclear war.

Without revealing too much of the authors' intriguing story line, suffice it to say that *Counterspace* reflects much of the current, real-world situation. The US Air Force and US Strategic Command (USSTRATCOM) worry about the fragility of satellite constellations upon which warriors daily depend; officers and enlisted troops alike bemoan the lack of "operationally responsive space" capabilities. Meanwhile, nations such as Iran and North Korea improve their nuclear and ballistic missile capabilities. China has demonstrated ground-based laser and ground-launched kinetic anti-satellite systems. Relatively inexpensive, small satellites enable poorer nations, for better or worse, to achieve some level of autonomy in outer space. And, the ubiquitous nature of the cyberspace domain allows individuals, businesses, and governments alike to manipulate electron flows for beneficial or nefarious purposes.

The authors allow US political and military leaders, who seek to fulfill their national security responsibilities, to draw from a vast range of real-world organizations, techniques, concepts, and cutting-edge inventions. Readers find members of the National Security Space Institute team characterized as "today's Billy Mitchells of milspace," and the Space Foundation as staying "on top of both national security and commercial space issues." Space tourism and an inflatable space habitat enter the equation, as do the airborne laser and non-nuclear electromagnetic pulse. Maneuvering spacecraft temporarily blind potentially hostile satellites, and real-time remote sensing from orbit combined with satellite communications stop the otherwise inevitable escalation of hostilities. Adaptive optics, autonomous systems, kinetic kill vehicles, and cyberwar come into play, even as generals on USSTRATCOM's battle staff struggle the reconcile actions with policy and doctrine. Like in *Space Wars*, Sun Tzu's philosophy and wargaming's efficacy remain central to success.



Scott, Coumatos, and Birnes have scripted *Counterspace* like a movie, with fades or cuts from scene to scene and place to place. Toward the end, as the plot thickens and narrative tension puts readers on the edge of their seats, some might experience déjà vu—shadows of *Fail Safe*. Not everything goes according to plan. There are casualties among friendly forces, and there is human weakness juxtaposed with heroism. Cleverly, the authors even include an all-too-human, ethically questionable personal relationship between two Air Force general officers. Almost certainly, if it has not happened already, some production company will pay a handsome price for the film rights to both *Space Wars and Counterspace*. Despite occasional lapses into triteness, these volumes constitute the core of an exciting, big-screen techno-thriller.

Serious readers might ponder several ideas expressed directly or indirectly in this novel. One is the importance of the relationship between human adaptability and survival. A Chinese official quotes American author Louis L'Amour as writing, "To exist is to adapt, and if one could not adapt, one died and made room for those who could." This same official explains to a special US emissary: "Your country, its people, are always adapting. The debate within your military and your government ensures this adaptability." A second lesson involves the strategic value of coordinated diplomatic and military actions, plus the tactical strength derived from integrated land, sea, air, space, and cyberspace capabilities. Another focuses on the potential advantages of national leaders using technology to stay audibly and visually in direct contact with each other during an intense crisis. Finally, in what some might perceive as an updated version of President Dwight Eisenhower's "Open Skies" doctrine, the authors suggest that selectively sharing imagery of US force posture in real time with a potential adversary might avoid a catastrophic miscue on the latter's part.

Even readers addicted to nonfictional literature could find themselves drawn into, perhaps hypnotized by, the action-adventure tale that Scott, Coumatos, and Birnes have concocted. Filled with plausible, frightening geopolitical scenarios involving characters with understandably human frailties, *Counterspace* mirrors a realistic future. As a former deputy secretary of defense has hinted, this science fiction might stimulate thinking and discussion among government, military, and defense-industry leaders in ways different from other genres.

Reviewed by Dr. Rick W. Sturdevant, deputy command historian, HQ Air Force Space Command.

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INTERNATIONAL SPACE

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